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REMOVAL OF ORGANIC AND EUTROPHYING POLLUTANTS BY CHEMICAL - BIOLOGICAL TREATMENT

Notre Dame University

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REMOVAL OF ORGANIC AND EUTROPHYING POLLUTANTS BY CHEMICAL - BIOLOGICAL TREATMENT

by

Department of Civil Engineering
University of Notre Dame
Notre Dame, Indiana 46556

for the

WATER QUALITY OFFICE

ENVIRONMENTAL PROTECTION AGENCY

Project #17010 DTG

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The principal objective ~~of this project~~ was to demonstrate, on a pilot plant scale (65,000 gallons per day) that a combined biological-chemical treatment scheme can effectively remove organic carbon, phosphorus and nitrogen from wastewater. The treatment scheme ~~investigated~~ consisted of: 1.) organic carbon removed by activated sludge type processes, 2.) phosphorus removal by chemical precipitation with aluminum, and 3.) nitrogen removal by biological-denitrification techniques. Process design loading factors developed ~~from this work~~ were: for nitrification, 0.09±0.03 mg ammonia nitrogen nitrified per day per mg mixed liquor volatile suspended solids (MLVSS) at a pH of 7.5 and temperature of 18°C, and for denitrification, 0.06 ± 0.02 mg of nitrite and nitrate nitrogen denitrified per day per mg MLVSS at a pH of 7.6 and temperature of 17°C. Final effluent total phosphorus residuals of approximately 1.0 mg/l were achieved using an aluminum to phosphorus molar ratio of 1.2 to 1.0. The total cost of wastewater treatment was estimated to be approximately 2.0 - 2.5 times that of conventional secondary treatment, at a flow of 10 MGD, with the addition of the nitrogen and phosphorus removal processes studied ~~in this project~~. (EPA)

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Institution Notre Dame University

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ABSTRACT

The principal objective of this project was to demonstrate, on a pilot plant scale (65,000 gallons per day) that a combined biological-chemical treatment scheme can effectively remove organic carbon, phosphorus and nitrogen from wastewater. The treatment scheme investigated consisted of: 1.) organic carbon removed by activated sludge type processes, 2.) phosphorus removal by chemical precipitation with aluminum, and 3.) nitrogen removal by biological-denitrification techniques.

Process design loading factors developed from this work were: for nitrification; 0.09 ± 0.03 mg ammonia nitrogen nitrified per day per mg mixed liquor volatile suspended solids (MLVSS) at a pH of 7.5 and temperature of 18°C and for denitrification; 0.06 ± 0.02 mg of nitrite and nitrate nitrogen denitrified per day per mg MLVSS at a pH of 7.6 and temperature of 17°C. Final effluent total phosphorus residuals of approximately 1.0 mg/l were achieved using an aluminum to phosphorus molar ratio of 1.2 to 1.0. The total cost of wastewater treatment was estimated to be approximately 2.0 - 2.5 times that of conventional secondary treatment, at a flow of 10 MGD, with the addition of the nitrogen and phosphorus removal processes studied in this project.

This report was submitted in fulfillment of Project Number 17010 DTG under the sponsorship of the Water Quality Office, Environmental Protection Agency.

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SECTION I

CONCLUSIONS

1. The project has demonstrated, on a significantly large operational scale, effective organic and inorganic pollutant removal from wastewater using a combined chemical and biological treatment scheme.

2. All three of the separate sludge systems operated very effectively with the nitrification system being the most sensitive to operational fluctuations. Continuous operational records for the pilot plant facility revealed percentage removals in the range of 90 - 95% for organic carbon (as BOD_5), total phosphorus and for total inorganic nitrogen.

3. Total phosphorus residuals in the final effluent from the pilot plant were maintained at a level of approximately 1.0 mg/l through a chemical addition in accordance with an aluminum to phosphorus molar ratio of 1.2 to 1.0.

4. A nitrification loading factor that can be used in wastewater treatment plant design was determined. This factor was 0.09 ± 0.03 mg ammonia nitrogen nitrified per day per mg of MLVSS at a pH of 7.5 and temperature of 18°C. Additional engineering design parameters which are suggested for the nitrification system are a solids retention time of 10 - 15 days and a food to microorganism ratio based upon ammonia nitrogen of 0.5.

5. A denitrification loading factor that can also be used in the engineering design of wastewater treatment facilities was determined. This factor was 0.06 ± 0.02 mg of nitrate and nitrite nitrogen denitrified per day per mg of MLVSS at a pH of 7.6 and temperature of 17°C.

6. Based upon a detailed cost evaluation of the pilot plant facility, it was discerned that improved wastewater treatment through addition of phosphorus removal and biological nitrification - denitrification to conventional secondary treatment facilities, with a capacity of 10 MGD, would increase the treatment costs by approximately 14¢ per 1000 gallons. The total cost for wastewater treatment utilizing the demonstrated pilot plant scheme is estimated to be from 2.0 to 2.5 times the costs for conventional secondary wastewater treatment.

SECTION II

RECOMMENDATIONS

1. Evaluation should be continued on each of the individual treatment methods studied as they are designed and operated in the field. Particular attention should be given to ascertaining the effect of different wastewaters and different climatic conditions on biological nitrification and denitrification.
2. Consideration should be given to refining the design, operation, and costs of each of the treatment processes.
3. The quantity and composition of sludge produced from each of the treatment processes should be determined and the effectiveness of various methods of sludge handling evaluated.
4. The compatibility of each of the individual processes studied with other treatment processes should be ascertained.

SECTION III

INTRODUCTION

The increased concentration of inorganic nutrients in domestic and some industrial wastewaters has received considerable attention in recent years because of their potential eutrophying effects on receiving bodies of water. In an attempt to limit the artificial fertilization of fresh waters by inorganic pollutants, various biological and chemical removal schemes have been proposed. Unfortunately, most of these treatment methods have been developed as tertiary treatment devices designed to follow conventional types of primary and secondary wastewater treatment units. Consequently, insufficient consideration has been given to the development of a complete and integrated treatment system optimally designed for the concurrent removal of both organic and inorganic pollutants.

The purpose of this project was to demonstrate by pilot plant techniques the operational characteristics and economic aspects of a combined biological and chemical treatment scheme for the removal of organic, nitrogenous, and phosphatic pollutants from wastewater.

The treatment scheme investigated consisted of:

1) organic carbon removal by activated sludge type processes,
2) phosphorus removal by chemical precipitation with aluminum, and
3) nitrogen removal by biological-denitrification techniques.

Previous laboratory studies have indicated the credibility of the individual aspects of this treatment scheme (1) (2) (3) (4) and the results of a 185 gpd continuous flow pilot plant study (5) have shown the apparent operational feasibility of the complete system. Through this demonstration project, a larger scale pilot plant facility (65,000 gpd) was constructed at the South Bend, Indiana wastewater treatment plant in order to further investigate the operating characteristics of this treatment scheme and to obtain engineering design and economic information.

A flow scheme for the pilot plant is shown in Figure 1. The pilot plant consisted of three completely mixed biological reactors each with separate settling tanks and sludge recycle capabilities. The first biological reactor was an activated sludge system designed for the removal of dissolved organic material. The second biological reactor was an aerobic nitrification reactor provided for the purpose of oxidizing dissolved nitrogen species (ammonia and nitrite) to nitrate. The final reactor was an anaerobic denitrification reactor designed for the reduction of nitrate nitrogen to elemental nitrogen gas. This reactor was mechanically stirred with a slowly rotating paddle and methanol was added as the external carbon source. A flash aerator was provided after this reactor (prior to the last settling tank) in order to condition the sludge (i.e., strip off nitrogen bubbles) for final settling. An alum solution was added directly to the first reactor (activated sludge system) in order to achieve phosphate precipitation; the aluminum phosphate precipitate was removed by settling in the first settling tank.

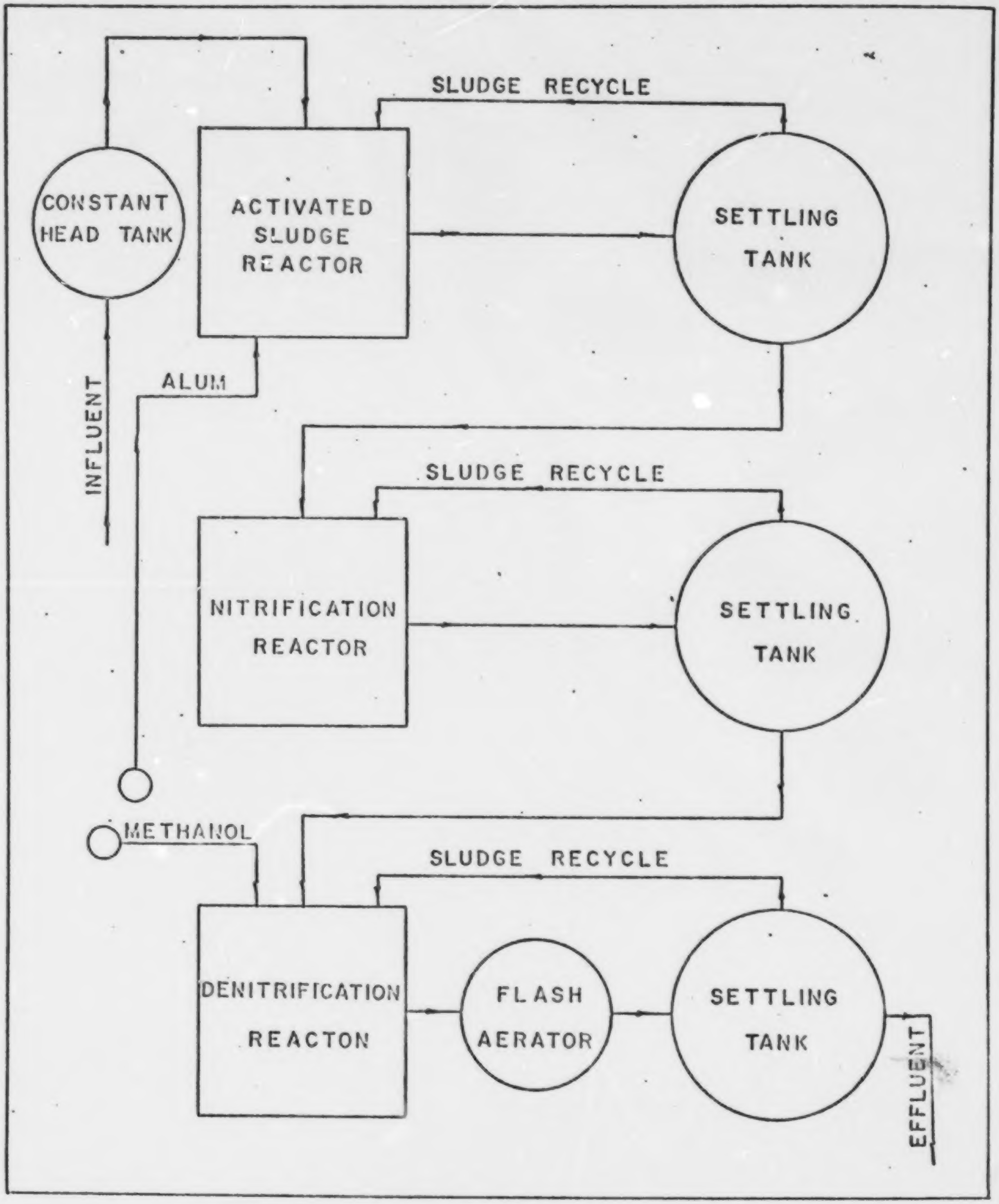

SLUDGE RECYCLE
CONSTANT HEAD TANK
ACTIVATED SLUDGE REACTOR
SETTLING TANK
ALUM
INFLUENT
SLUDGE RECYCLE
NITRIFICATION REACTOR
SETTLING TANK
METHANOL
SLUDGE RECYCLE
DENITRIFICATION REACTON
FLASH AERATOR
SETTLING TANK
EFFLUENT

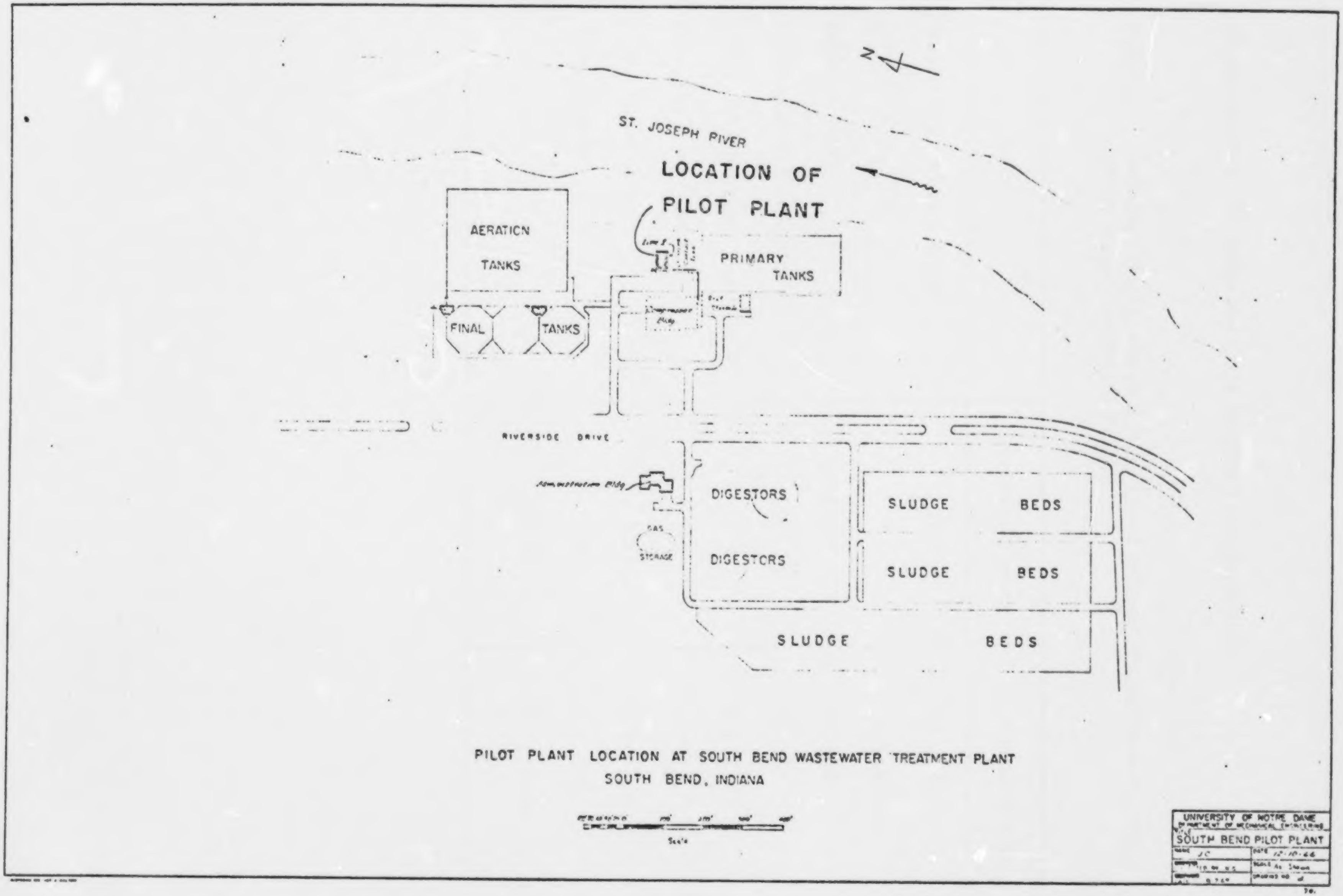
Figure 1: Flow Scheme of Pilot Plant.

The project consisted of three major phases:

1) Phase I: Design and construction of the pilot plant facility.
2) Phase II: Determination of the operational characteristics of the treatment process.
3) Phase III: Evaluation of the operational and economic aspects of the treatment scheme.

Figure 2 indicates the site plan of the South Bend, Indiana Wastewater Treatment Plant and the location of the pilot plant. The South Bend Wastewater Treatment Plant has been in operation since August 1956. This plant currently consists of grit removal, comminution, pre-aeration, primary sedimentation, activated sludge, final clarification, chlorination (not currently employed) and anaerobic digestion facilities. Phosphate removal and sludge thickening facilities are currently under construction. The plant has a capacity of 40 MGD and treats the domestic and industrial wastewaters of the greater city of South Bend, Indiana. The effluent is discharged into the St. Joseph River which has a mean annual flow in the range of 3500-4000 cfs and flows 46 miles in a general northeasterly direction from South Bend where it ultimately discharges into Lake Michigan at Benton Harbor - St. Joseph, Michigan.

Raw wastewater (after comminution) was used as influent to the pilot plant throughout the study. Table I indicates average values (and ranges) of the most pertinent water quality parameters observed in the raw wastewater during the study. Copies of the monthly operational reports for the South Bend Wastewater Treatment Plant as submitted to the State of Indiana during the period


ST. JOSEPH RIVER
LOCATION OF PILOT PLANT
N
AERATION TANKS
PRIMARY TANKS
FINAL TANKS
RIVERSIDE DRIVE
Administration Bldg
GAS STORAGE
DIGESTORS
DIGESTORS
SLUDGE BEDS
SLUDGE BEDS
SLUDGE BEDS
PILOT PLANT LOCATION AT SOUTH BEND WASTEWATER TREATMENT PLANT
SOUTH BEND, INDIANA
Scale
UNIVERSITY OF NOTRE DAME
DEPARTMENT OF MECHANICAL ENGINEERING
SOUTH BEND PILOT PLANT
JC
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As Shown

Figure 2: Plan of South Bend Wastewater Treatment Plant Showing Loaction of Pilot Plant.

SECTION IV

THEORETICAL CONSIDERATIONS AND PREVIOUS WORK

This section discusses the theoretical considerations and previous work reported in the literature on topics related to this study. The removal of three major classes of pollutants (carbonaceous, phosphatic, and nitrogenous) were studied in this project and individual sub-sections discussing the theoretical aspects of their removal follow. Since appreciably more research (and field evaluation) has been performed on the removal of carbonaceous pollutants than on the removal of phosphatic and nitrogenous pollutants and the emphasis of this study was on the removal of the latter elements --- only certain aspects of the biological removal of carbonaceous material are discussed; i.e., rather than attempt to discuss the various aspects of activated sludge operation the basic elements of biological treatment were discussed. The material presented in this sub-section (Biological Removal of Carbonaceous Pollutants) is applicable to all the biological systems employed in this study.

Biological Removal of Carbonaceous Pollutants

The removal of carbonaceous pollutants was accomplished in this project by complete mixing of activated sludge. Numerous references exist regarding this process. In the design and operation of this process, as in any biological treatment system, the two basic design considerations are:

1) providing environmental conditions satisfactory for the removal of pollutants from the wastewater due to the metabolic activities of the microorganisms, and

2) insuring that suitable provision is made for the removal of the microorganisms from the treated wastewater after they have fulfilled their metabolic role.

These design requirements should be viewed in terms of a consideration of 1.) the reactor kinetics, and 2.) the flocculation of the system, respectively.

Kinetics of the Biological Removal of Organic Material. Numerous papers have been published which describe the kinetics of substrate removal by biological systems. Excellent reviews of the technical literature on this subject as it relates to biological wastewater treatment have been published by Gaudy and Gaudy (6), among others. For the most part, the basic premise in each development follows the classical treatment of Herbert (7), which states that the growth of microorganisms with respect to time is a function of the mean cell division rate times the instantaneous concentration of microorganisms. This relationship was originally reported by Monod (8) for a pure culture of microorganisms through which a single substrate was passed in a continuous flow. The mean cell division rate was reported to vary with the substrate concentration and was mathematically expressed by a function similar to the Michaelis-Menten equation for enzymatic reactions.

These relationships, or closely similar ones, have been utilized to predict such parameters as substrate concentration, cell concentration, and biomass yield from biological reactors under either batch or continuous flow operation.

Mode of Biological Flocculation. In order to achieve effective separation of the microorganisms from the treated wastewater after they have fulfilled their metabolic role they must be in a flocculated form as opposed to being in a dispersed state. This requirement is a prerequisite for effective operation of any type of separation device, e.g., gravity settling tank, upflow clarifier, centrifuge, filter, etc. In general terms, flocculation consists of agglomerating the otherwise discrete microorganisms into flocs or packets so structured that under quiescent conditions they will have sufficient magnitude to subside from suspension or that if filtered or centrifuged the flocs will have sufficient rigidity and associated porosity that effective withdrawal of water can be achieved.

A review of the literature pertaining to biological flocculation indicates that several distinct theories on the subject have been supported throughout the last century (e.g., electrostatic charge relationships, specific species such as Zoogloea, protozoa induced, flaggella induced, capsular theory). Studies in our laboratory have indicated that biological flocculation relationships such as those shown in Figure 3B are typical for both mixed cultures of heterotrophic and autotrophic microorganisms (9) (10). Characteristically, microorganisms are dispersed during the periods of rapid growth (high ratio of substrate to microorganism mass); whereas, in periods of limited growth (low ratio of substrate to microorganism mass) agglutination occurs. Such phenomena can be explained by a consideration of the amount of exocellular polymer present with respect to the mass, or surface area, of the microorganisms present. These relationships are evident from the data presented in Figure 3 which indicate the accumulation of exocellular polymer (Figure 3C)

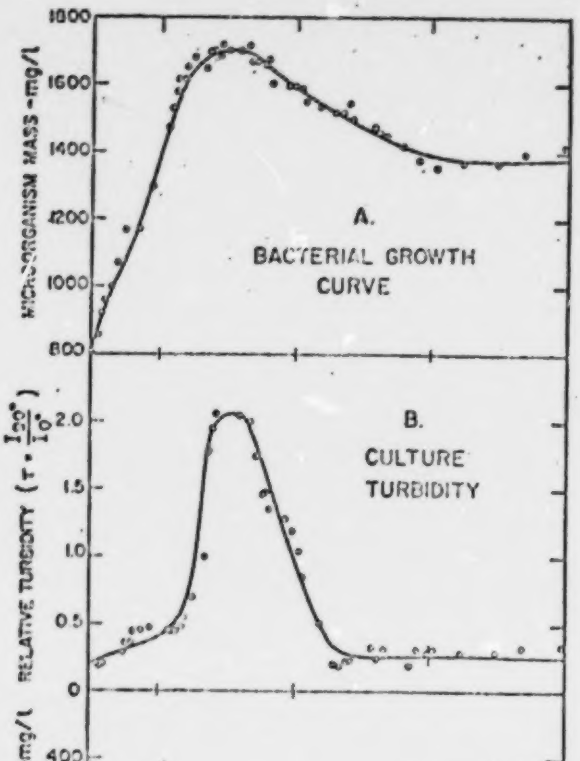


FIGURE 3

Relationship between biological growth phase (Fig. 3A) and biological flocculation (Fig. 3B). Also shown are the accumulation of exocellular polymer (Fig. 3C) and the ratio of accumulated exocellular polymer to microorganisms (Fig. 3D).

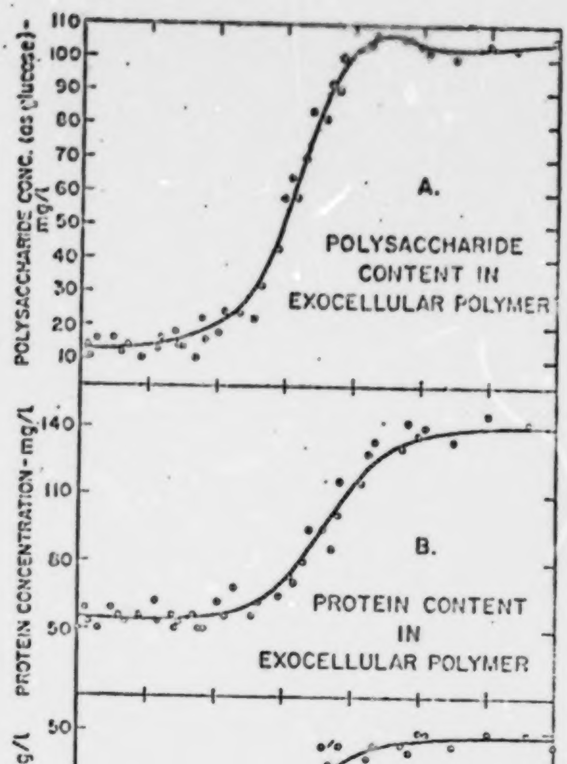


FIGURE 4

Concentration of Major Components of Exocellular Polymer as a function of biological growth phase.

as a function of growth stage (Figure 3A). The data shown in Figure 3 were obtained from a batch study of heterotrophic bacteria utilizing nutrient broth as substrate; these data are typical of numerous other substrates for heterotrophic bacteria as well as being representative of autotrophic activity. In the study indicated, the extent of bacterial flocculation was ascertained by light scattering techniques and is represented as culture turbidity in Figure 3B. The importance of the ratio of exocellular polymer to microorganisms mass for biological flocculation is clearly illustrated by comparing Figures 3D and 3B. Certainly, flocculation will not occur until sufficient polymer has accumulated with respect to the microbial mass to overcome the dispersion forces inherent to the system, e.g., agitation, surface charge, etc.

The exocellular material is microbially produced, is relatively refractory to heterotrophic degradation, and thus accumulates as shown. During long periods of endogenous respiration, however, heterotrophic microorganisms will result (similar relationships will occur in most autotrophic wastewater treatment systems due to the fact that some heterotrophic microorganisms are also generally present). The exocellular material could originate as a waste product of metabolic activity or as polymeric fractions dispersed from cell autolysis. In view of the fact that the operation of conventional biological wastewater treatment systems relies on re-seeding with flocculated microorganisms, it is not surprising to observe that the compositional makeup of the major constituents of the exocellular materials associated with cellular agglutination are remarkably similar in different types of biological reactors, since the flocculated cells are being returned while the others are lost from the system. Four general categories of organic polymers have been found to be present in all of the exocellular extracts from such microbial systems: polyssacharide, protein, RNA, and DNA. Typical relationships for these constituents (corresponding to the data reported in Figure 3) are shown in Figure 4.

The phenomenon of biological flocculation can be interpreted as resulting from the flocculant action of the exocellular polymeric material. In this regard, biological autoflocculation follows relationships similar to those observed in the chemical flocculation of microorganisms (2) (11). The essence of cell agglutination is based on the chemical and/or electrostatic bonding of polymeric materials to the surface of a cell with subsequent bridging of extended polymeric segments for bonding to other cellular surfaces and/or attachment to other extended segments. In this fashion, a three-dimensional matrix or floc is formed. In order to achieve polymer bridging between cells, the polymeric segments must either be sufficiently extended to overcome the effective distance of the net charge of repulsion due to the like electrostatic sign of the cells or the net surface charge on the cells must be reduced. If polymeric bridging between cells is to be achieved, the resulting efficiency of biological flocculation will be governed by the extent of polymeric surface coverage of the cells; e.g., insufficient polymeric coverage will result in redispersion due to insufficient bridging to withstand the forces of agitation and excessive coverage also will cause redispersion due to the unavailability of vacant sites for extended segment bonding.

Numerous environmental factors will influence biological flocculation; some of the more significant factors include: pH, temperature, ionic strength, concentration of polyvalent ions, and agitation.

Chemical Precipitation of Phosphate.

Many metal ions are effective in precipitating phosphate from solution. Due to their relatively low cost and general availability, the three most frequently used metals for phosphate precipitation are calcium, iron, and aluminum. An examination of Table 2 reveals that all three of these metals form relatively insoluble precipitates with phosphate.

Table 2: Equilibrium Constants Related to Phosphate Precipitation with Metal Ions.

No.	Reaction	Log Equilibrium Constant, 25° C
1.	$Fe^{+3} + PO_4^{-3} = FePO_4(s)$	23
2.	$3Fe^{+2} + PO_4^{-3} = Fe_3(PO_4)_2(s)$	30
3.	$Al^{+3} + PO_4^{-3} = AlPO_4(s)$	21
4.	$Ca^{+2} + 2H_2PO_4^{-} = Ca(H_2PO_4)_2(s)$	1
5.	$Ca^{+2} + HPO_4^{-} = CaHPO_4(s)$	6
6.	$10Ca^{+2} + 6PO_4^{-3} + 2OH^{-} = Ca_{10}(OH)_2(PO_4)_6(s)$	90

The tendency of aluminum and iron to hydrolyze in aqueous solution creates a competition between the hydroxide and phosphate ions for the coordination sphere of the metal. Thus the efficiency of phosphate removal is dependent upon the relative concentrations of these two anions in solution and is consequently pH dependent. A decrease in pH, or, more precisely, (OH^-), favors precipitation of the metal phosphate. However, since the solubility of the metal phosphates increases with decreasing pH, an optimum pH exists for the removal of phosphate with metal ion precipitants. When calcium is used as a precipitant, the competition for calcium is predominantly between the phosphate and carbonate anions and, again, phosphate removal is dependent upon the relative concentrations of the anions present, and upon pH. Hydroxylapatite, $Ca_{10}(OH)_2(PO_4)_6$, is the most stable calcium phosphate solid phase as shown in Table 2.

Cost figures for commonly used metal ion containing compounds are shown in Table 3. Although lime is indicated in Table 3 as being the least expensive metal ion (i.e., in terms of ¢/lb metal ion), it can be shown from the equilibrium constants indicated in Table 2 for reactions 4-6, that effective phosphate precipitation with lime requires pH values in excess of 10.0. Since this pH is not conducive to operation of conventional activated sludge type systems, lime can not be used for phosphorus precipitation within an activated sludge system, but rather requires the added expense of separate treatment tanks and pH neutralization prior to ultimate discharge.

Iron was not selected for phosphate precipitation because of the potential reduction of ferric phosphate during anaerobic conditions such as in anaerobic digestion and the resolubilization of phosphate (see Table 2). Aluminum thus appeared to be the most desirable metal ion for phosphate precipitation in this case. Of the two most commonly used aluminum compounds, sodium aluminate

Table 3: Approximate Costs of Selected Inorganic Coagulants.

Common Name	Chemical Formulation (Commercial)	Fraction Metal Ion	Cost Per Ton	Cost per lb. of Metal Ion (¢/lb Metal Ion)
Alum	$Al_2(SO_4)_3 \cdot 17H_2O$	0.083	\$ 65	39.2
Sodium Aluminate	$NaAlO_3$	0.430	\$ 150	17.4
Ferric Chloride	$FeCl_3$	0.345	\$ 180	26.0
Ferric Sulfate	$Fe_2(SO_4)_3$	0.280	\$ 50	8.9
Lime	CaO	0.714	\$ 20	1.4

*Approximate local prices in Chicago area (June 1971); prices subject to appreciable variation particularly with respect to transportation distance.

has a definite advantage in terms of cost per lb of metal ion and has been shown to be effective in similar systems (12). Alum was selected for this study, however, because of its ability to lower the pH resulting in lower overall requisite aluminum dosages (see Figure 5). Under favorable pH conditions, the requisite concentration of Al(III) for the removal of phosphate closely approximates the one to one Al to PO_4 ratio which should theoretically exist in accordance with reaction 1 shown in Table 2. This is confirmed by the "filtered" line of Figure 6 which was experimentally determined at a constant pH of 6.0. The filtered line of Figure 6 was obtained by filtering the insoluble $AlPO_4$ from solution. Operationally, where filtration may be impractical, excess Al(III) must be added to effect useful phosphate removal as shown by the settled line in Figure 6. In this case, although the phosphate has been rendered insoluble

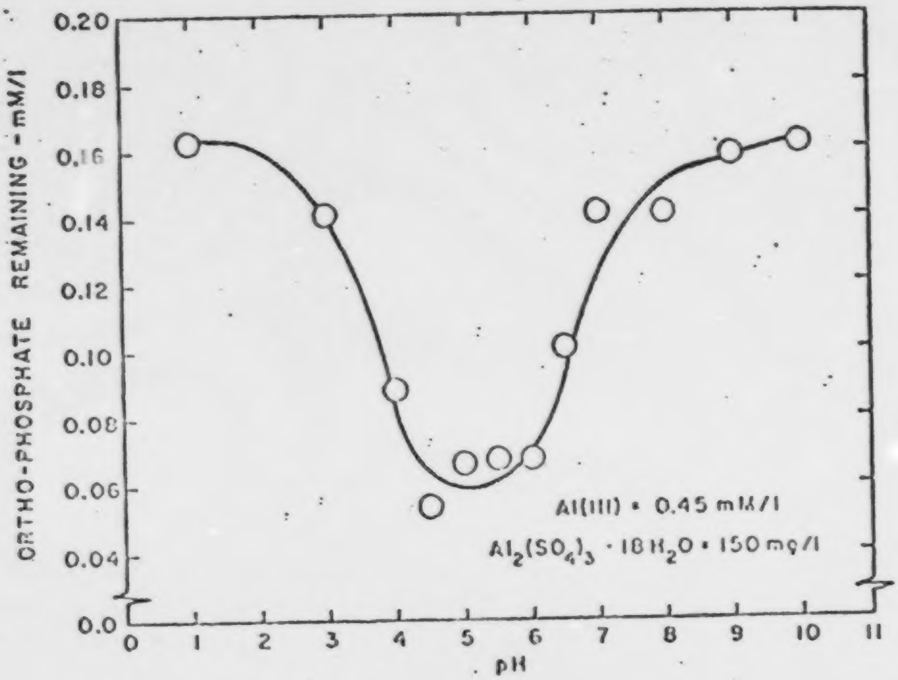


Figure 5: The Effect of pH on the Removal of Ortho-Phosphate with Aluminum (after Tenney and Stumm (2)).

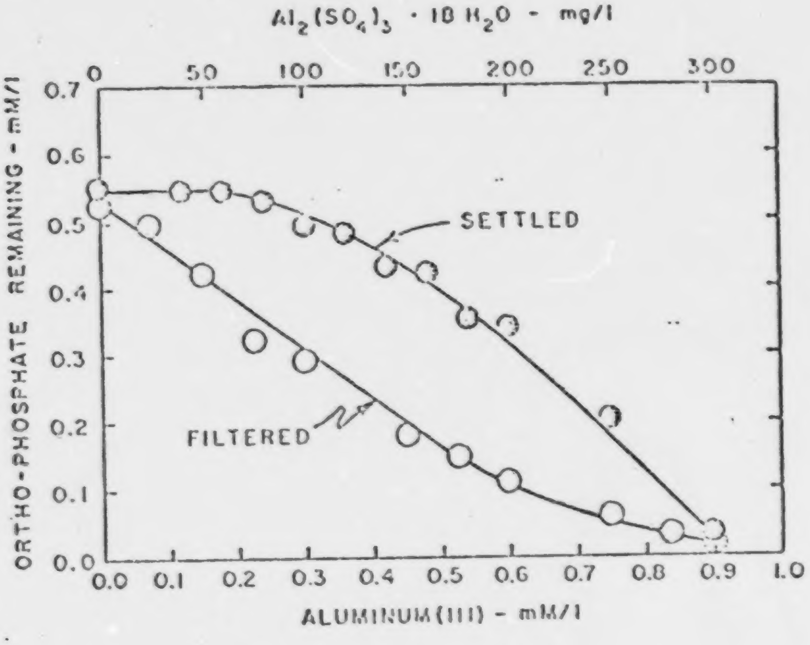


Figure 6: Removal of Ortho-Phosphate with Aluminum (after Tenney and Stumm (2)).

by the aluminum, additional Al(III) is required as a coagulant. It must be realized that chemical precipitation of phosphate is a two-stage process:

1.) the phosphate must be made insoluble through the use of metal ions; and

2.) the precipitate must be removed from solution by sedimentation.

The addition of various polyelectrolytes, or the addition of excess metal ions to form metal hydroxides serve identical purposes in bringing about agglomeration of the insoluble metal phosphate particles into a settleable mass.

Although it has been shown that microorganisms, such as those predominating in activated sludge systems, exert a coagulant demand (i.e., an aluminum demand), it is convenient to observe that aluminum will preferentially precipitate phosphorus when added to such systems. Experimentally determined data, typical of such phenomena, are shown in Figure 7. This figure indicates clearly the preferential affinity of aluminum for phosphate over that of the microorganisms. An Al/P ratio close to 1.0/1.0 can be observed in this system and it is not until the phosphorus concentration is appreciably reduced that any aluminum goes to the surface of the microorganisms. Thus, aluminum can be added directly to activated sludge aeration tanks for phosphate precipitation and only small amounts, if any, would be expected to be lost to satisfy microbial demands. Care must be exercised that sufficient phosphorus is left in solution to fulfill the nutrient requirements of the microorganisms, however.

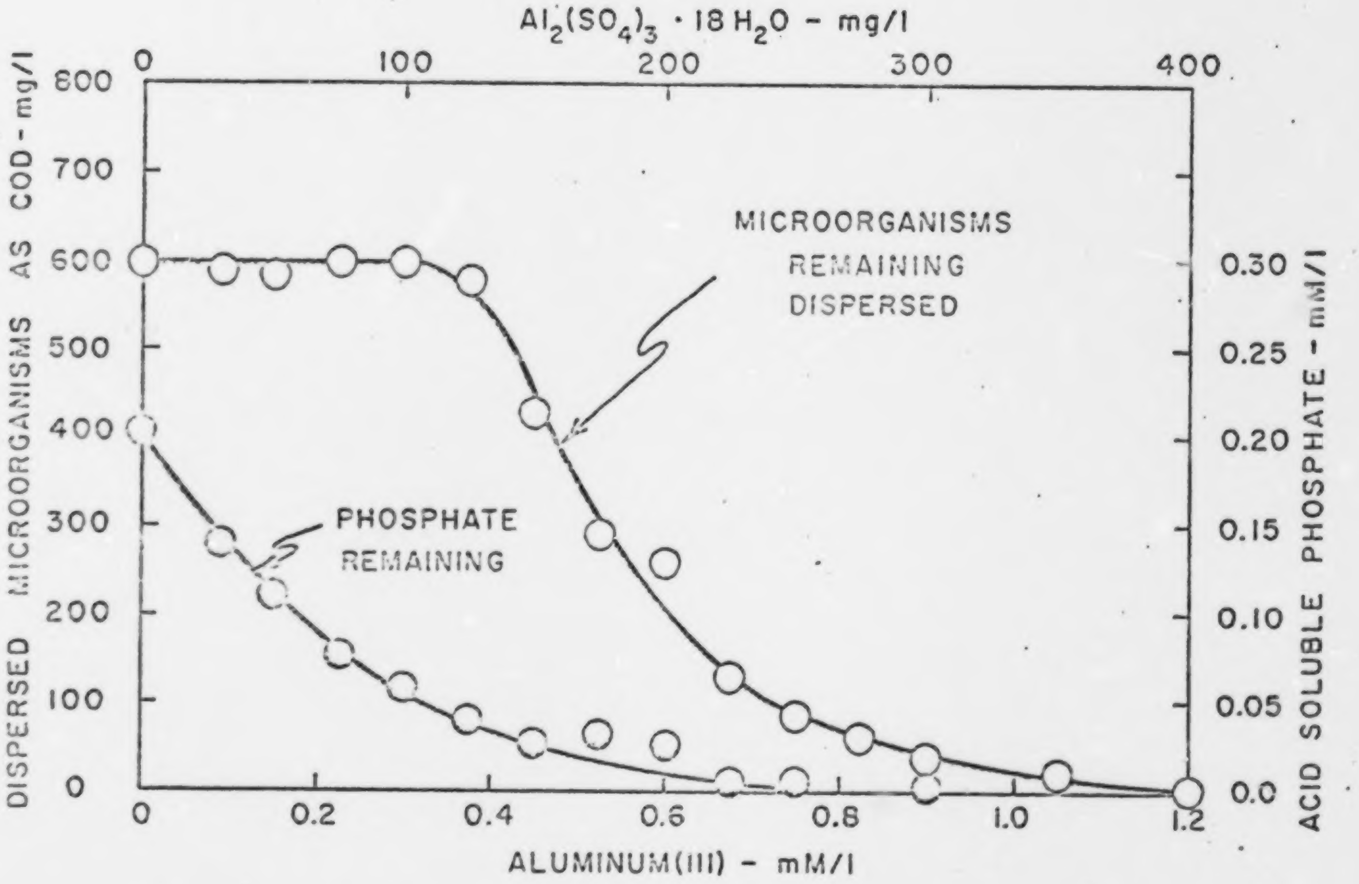


Figure 7: Phosphate Precipitation in the Presence of Activated Sludge Type Microorganisms (after Tenney and Stumm (2)).

Biological Removal of Nitrogen

The biological transformations inherent to the nitrogen cycle form the basis for nitrogen removal by biological treatment. A major advantage of achieving nitrogen removal in this fashion is that all forms of nitrogen ultimately are removed from solution in the non-polluting form of nitrogen gas. Two steps are involved in the biological removal of nitrogen:

1.) nitrification--the oxidation of ammonia forms to nitrate and
2.) denitrification--the subsequent reduction of nitrate to nitrogen gas.

(N. B. Denitrification cannot occur without prior conversion of nitrogen forms to nitrate.)

Nitrification. The oxidation of ammonia to nitrate is a two-step process if carried to completion. Initially, ammonia is oxidized to nitrite; five genera within the Nitrobacteraceae family are generally considered for this step (13). This genera is headed by the Nitrosomonas bacteria, a strict aerobic autotrophic bacteria that utilize ammonia as their sole source of energy. The stoichiometry of this reaction is shown in equation 1. The second step, the conversion of nitrite to nitrate is accomplished principally by two other genera of the Nitrobacteraceae family (13). This genera is headed by the Nitrobacter bacteria, a strict autotrophic bacteria that utilize nitrite as their sole energy source. The stoichiometry of this reaction is shown in equation 2. The overall nitrification reaction is represented by the summary equation (equation 3)*.

---

* It can be discerned from equation 3, that 1.0 mg/l a ammonia nitrogen (as N) requires 4.6 mg/l of dissolved oxygen for complete nitrification.

$$2NH_4^+ + 3O_2 = 2NO_2^- + 2H_2O + 4H^+ \tag{1}$$

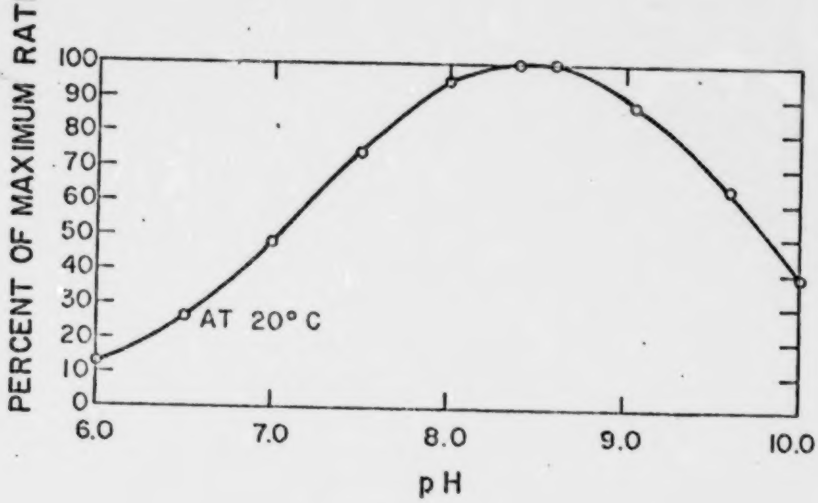
$$2NO_2^- + O_2 = 2NO_3^- \tag{2}$$

$$NH_4^+ + 2O_2 = NO_3^- + 2H^+ + H_2O \tag{3}$$

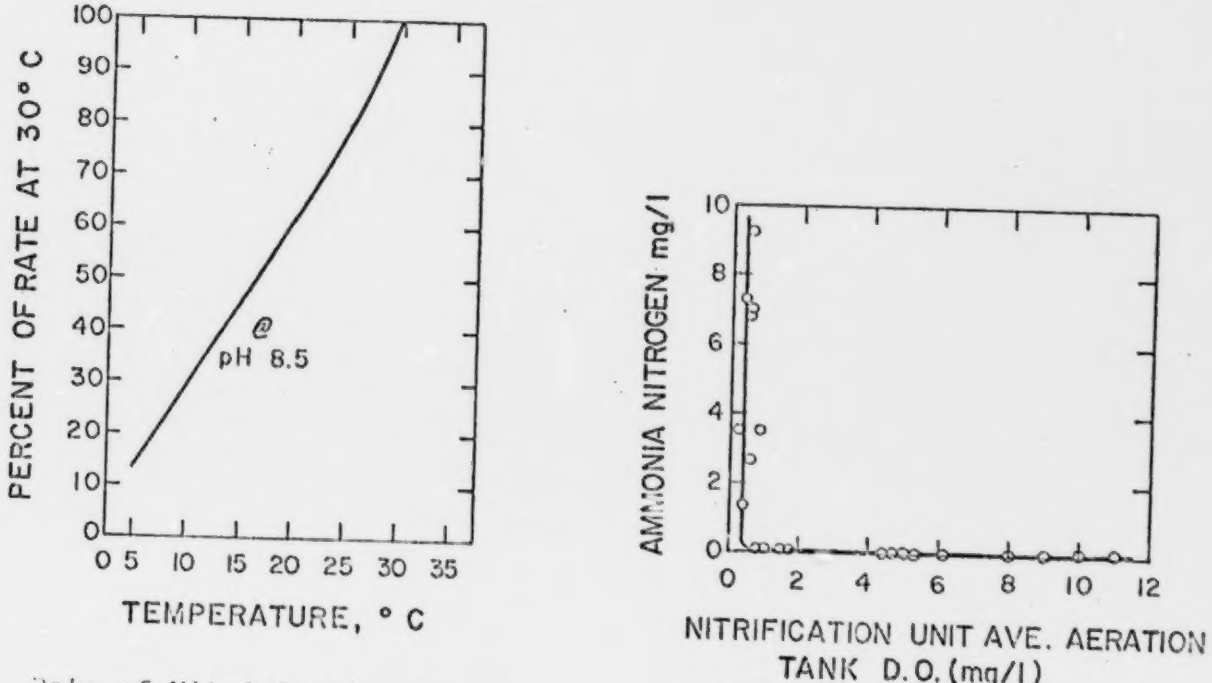
Although it has been reported (14) that a number of heterotrophic organisms are also capable of nitrification, it appears that the organisms of major importance in nitrification are the Nitrosomanas and Nitrobacter species (15)(16). These autotrophic bacteria utilize carbon dioxide as a carbon source. These particular organisms have long generation times which are significantly influenced by pH, temperature, and the concentration of residual dissolved organic material.

In attempting to obtain nitrification in wastewater treatment, two different approaches have been taken; first, to accomplish carbon removal and nitrification concurrently (or more precisely, sequentially) in the same reactor and second, to have separate reactors, one each for carbon removal and nitrification. In combined activated sludge nitrification systems, nitrification will develop if the "Load Factor" as defined by Johnson and Schroepfer (17) (lbs BOD/day/lbs VSS) is maintained near 0. 3 or below. This "Load Factor" is a function of both MLVSS and detention time; a "Load Factor" of 0. 3 or less would correspond to a sludge age equal to or greater than 4 days. They define sludge age as the ratio of suspended solids under aeration to the BOD added per day. Wuhrmann (18) stated that the fundamental parameter for controlling nitrification is sludge age, which he defines as the proportion of the amount of sludge present in the system to the sludge released from the plant, and that the nitrification process will be complete as soon as conditions for the buildup of the nitrifiers are satisfied. He found these conditions to be a sludge age of two days in the 14° - 17° temperature range, while a five day sludge age was required in the 8° - 11°C range. Wuhrmann (19) also revealed that in high rate systems (i.e., high BOD/MLSS ratios) even at sludge concentrations of 6000 mg/l, nitrification did not develop. For complete nitrification, Johnson (20) estimated that fifty percent more air would be required than for BOD stabilization alone.

Downing and Wheatland (21) have suggested that effective nitrification might best be obtained in a two stage operation: the first, high rate activated sludge for carbon removal, the second, clarification and biological nitrification. This separation has the distinct advantage of separating the two classes of microbial species, i.e., heterotrophic in the first stage and autotrophic in the second stage. Wild, et al. (22), working with separate carbon and nitrification reactors, have shown the optimum pH for nitrification to be 8.4, and also that 90 percent of this optimum rate can be achieved in the pH range of 7.8 - 8.9 (see Figure 8A). They have further shown that the rate of nitrification continuously increases through the temperature range of 5° - 30°C (Figure 8B) and that dissolved oxygen levels greater than 1.0 mg/l were assurance that adequate oxygen was present (see Figure 8C). DeMarco, et al. (23) found that the rate of nitrification increased with increasing seed concentration and agitation and with decreasing organic concentration. Mulbarger (24) noted



A. Percent of Maximum Rate of Nitrification
at Constant Temperature vs pH.



B. Rate of Nitrification at all
Temperatures Compared to the Rate
at 30°C.

C. The Effect of Dissolved
Oxygen Conc. on Nitrification

Figure 8: Effect of Various Parameters on Biological Nitrification
(After Wild, et al. (22)).

that adequate wastewater buffering must be available in order to have nitrification occur. Theoretically, 7.1 mg of calcium carbonate alkalinity are required for each mg of nitrate nitrogen produced. Equation 3 depicts this alkalinity demand due to hydrogen ion release.

It is axiomatic that the extent of nitrification in any microorganism system is dependent on the number of nitrifying organisms present and the rate at which these organisms oxidize ammonia to nitrate. The number of nitrifying organisms present in a system is dependent, among other variables, on the substrate available and the cell yield constants of the microorganisms. The rate of ammonia oxidation constants and the cell yield constants that have been reported in the literature vary over a wide range of values.

McCarty and his co-authors (25) (26) (27) in a series of papers presented information on nitrification. The basis for this information was the first paper (25) in which they studied biological synthesis and growth from a thermodynamic viewpoint. In that first paper, McCarty determined constants from the work of Hofman and Lees (28) from which he obtained a Nitrosomonas yield figure of 0.29 g of cells per gram of ammonia nitrogen oxidized. An investigation of McCarty's calculations resulted in the conclusion that the 0.29 g figure was probably obtained by assuming a nitrogen/carbon ratio of 7.4 which from Hofman and Lees' (28) work would amount to a nitrite nitrogen concentration of 90 mg/l. Ninety mg/l of nitrite nitrogen is a concentration not ordinarily experienced in sanitary engineering situations. Stratton and McCarty (27) determined a waste removal coefficient using this calculated yield figure as a basis of analysis. Therefore, if the initial bacterial cell yield figure was erroneous, the substrate utilization constants and initial bacterial concentrations calculated using this yield figure would be questionable. Wezernak and Gannon (29) were extremely critical of the procedure used by Stratton and McCarty (27). Three specific areas of criticism were: 1.) estimating a cell yield constant form theoretical considerations on the thermodynamics of growth; 2.) the use of an estimated cell yield constant as a basis for calculating two other unknowns; 3.) using the computer to estimate field nitrifying conditions based on simple laboratory batch tests.

Knowles, _et_ _al_. (30) noted that the kinetics of growth of both the _Nitrosomanas_ and Nitrobacter organisms appear to conform fairly closely to an equation of the Michaelis type. However, Downing (31) later stated that the ammonia concentration in wastewater is much greater than the low ammonia concentration below which the rate of growth becomes concentration dependent.

Downing and his co-workers in a number of papers (21) (31) (32) (38) (34) discuss various aspects of nitrification. They found the growth constant for _Nitrosomonas_ in mixtures of domestic wastewater and activated sludge roughly doubled for each $7^{\circ}C$ increase in temperature and that the growth constant was also affected by pH in the 6.0 - 7.2 range. For pH changes in the 7.2 - 8.0 range, the growth constant remained relatively constant. They presented equation 4 as a summary of their temperature and pH findings

$$k = 0.18 - 0.15\,(7.2 - p)\,e^{0.12(T-15)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

where k = growth rate constant for Nitrosomonas - $days^{-1}$

p = measured pH if the pH is in the range of 6.0-7.2

= 7.2 for measured pH's in the range 7.2-8.0

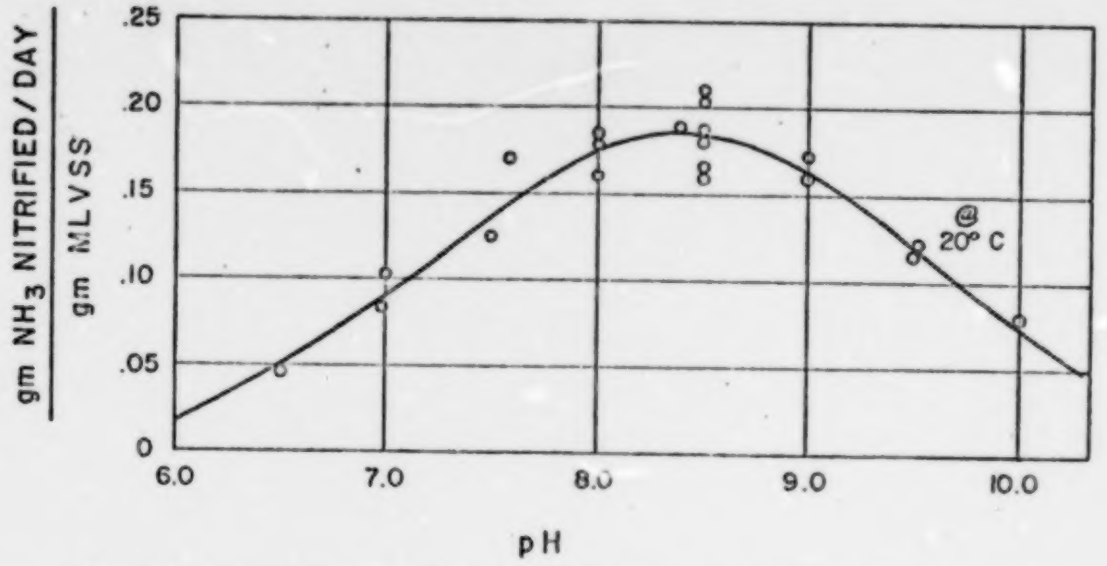
T = temperature in °C

Downing used the k values derived from equation 4 in other equations to determine if nitrification would develop in activated sludge systems.

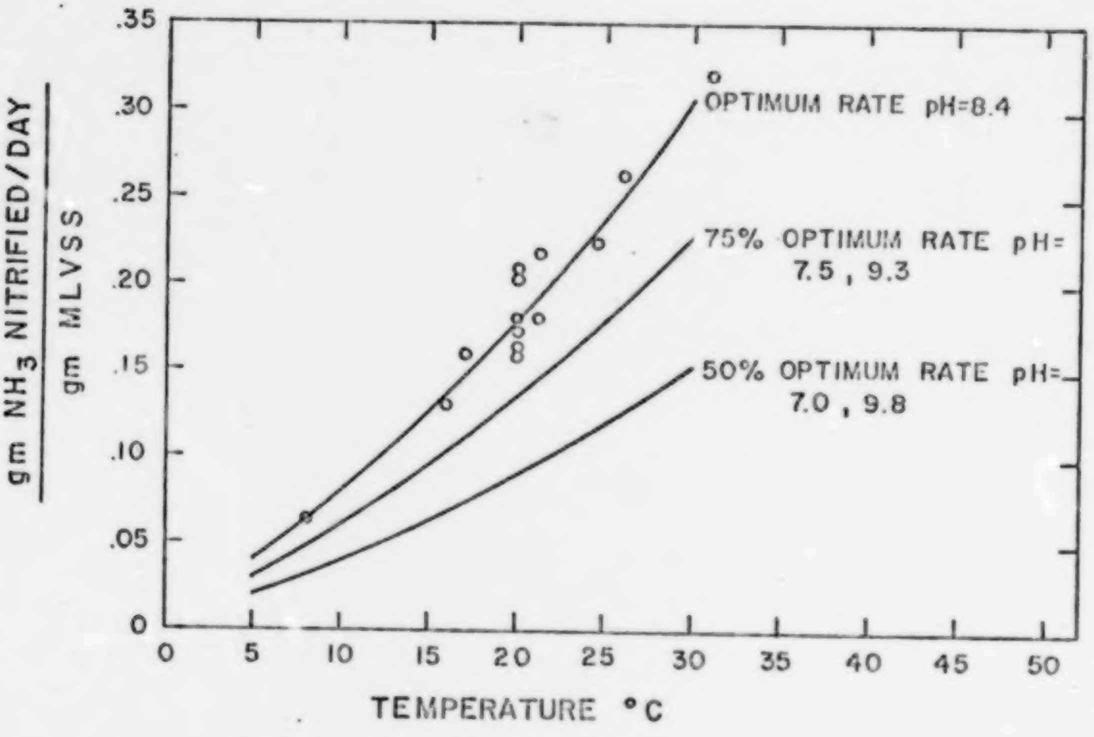
Other parameters known to effect nitrification in biological systems are sludge concentration, influent BOD and sludge recycle ratio. The cumulative effect of these factors comprise what Johnson and Schroepfer (17) refer to as sludge age, which is inversely proportional to the load factor.

Additional data on nitrification rates was reported by Wild et al. (22) and is shown in Figure 9. Figure 9A indicates the variation observed in their studies in the rate of nitrification with pH and Figure 9B indicates the variation in the rate of nitrification with temperature. A review of these data indicate that a nitrification rate in the range of 0.05 - 0.20 gms NH_3 nitrified/day/gm MLVSS might be expected in operating conditions depending on the pH and temperature.

Denitrification. Biological denitrification is achieved under anaerobic conditions by heterotrophic microorganisms which in their metabolism utilize nitrate as a hydrogen acceptor if an organic energy source is available.



A. Rate of Nitrification versus pH at Constant Temperature



B. Rate of Nitrification versus Temperature at Various pH Levels

Figure 9: Effect of pH and Temperature on Nitrification Rate (After Wild, *et al.* (22)).

McCarty, et al, (36) have reported that a wide variety of common facultative bacteria can accomplish denitrification (e.g., Pseudomonas, Achromobacter, Bacillus). The specific denitrifying capacity of these microorganisms can differ, however. Some can reduce only nitrates to nitrites, some can reduce only nitrites to molecular nitrogen, and some can achieve the reduction of both nitrates and nitrites to molecular nitrogen. Thus, denitrification must be considered as a two-step process.

$$NO_3^- + 1/3\ CH_3OH = NO_2^- + 1/3\ CO_2 + 2/3\ H_2O \quad \text{.................} \quad (5)$$

$$NO_2^- + 1/2\ CH_3OH = 1/2N_2 + 1/2\ CO_2 + 1/2\ H_2O + OH^- \quad \text{..........} \quad (6)$$

$$NO_3^- + 5/6\ CH_3OH = 1/2N_2 + 5/6\ CO_2 + 7/6\ H_2O + OH^- \quad (7)$$

If, for example, methanol is selected as the organic carbon source to provide energy for bacterial synthesis, equations 5-7 represent the microbially-induced nitrogen transformations characteristic of denitrification. Equation 5 indicates the reduction of nitrate to nitrite, equation 6 the reduction of nitrite to molecular nitrogen, and the overall reaction is indicated by equation 7.

Busch (36) points out that the enzymes responsible for this process are specific for nitrate and nitrite and that these oxidized nitrogen ions are the hydrogen acceptors, not the bound oxygen in these ions. Furthermore, Busch stated that these enzymes are inhibited by the presence of dissolved oxygen. This proposition has been contested by Mechsner and Wuhrmann (37) through their findings that some bacterial species denitrify over a range of dissolved oxygen concentrations, including some that denitrify at high dissolved oxygen levels.

It can be observed from equation 7 that 5/6 moles of methanol are required to completely reduce one mole of nitrate to molecular nitrogen. For high percentages of nitrogen removal then, stoichiometric amount of organic material must be added, or the nitrate may be reduced only to nitrite, and no nitrogen removal occurs. External sources of carbon are generally selected rather than raw or partially treated wastewater -- because of the large fraction of non-oxidized forms of nitrogen generally present in such wastewaters.

McCarty, et al. (35) studied the use of organic compounds as electron donors for biological denitrification. They selected five organic compounds; methanol, acetic acid, ethanol, acetone and sugar because of their low cost, water solubility and probable ease of biodegradation. These authors indicated that stoichiometric equations can be developed to predict the quantity of organic compound required to denitrify. These predictions, however, will always be exceeded because additional amounts of organic material will always be required for biological synthesis. To define the total quantity of organic compound required, McCarty, et al. (35) developed a consumptive ration (C_r) which they define as, "the ratio of the total quantity of an organic compound consumed during denitrification to the stoichiometric requirement for denitrification and deoxygenation alone." They presented a listing of half cell reactions for both the oxidation of the five organic compounds studied and the reduction of oxygen and the nitrogen compounds of interest. All these half cell reactions were based on an equivalent quantity of compound required to transfer one mole of electrons. These authors then empirically determined consumptive ratios by measuring organic carbon and nitrogen removal from biological systems, referred to the half cell reaction for equivalent comparison and calculated using equation 8:

$$C_r = \frac{\text{Equivalent Decrease in Dissolved Organic Carbon}}{\text{Equivalent Decrease in } NO_3 + NO_2 + O_2} \quad \ldots\ldots\ldots\ldots (8)$$

They discovered that all of the compounds studied, except sugar, had consumptive ratios in the 1.30 - 1.40 range. Based on the consumptive ratio results, chemical costs, and vapor pressure considerations, methanol was recommended as most suitable for the biological denitrification energy supply.

By using the half cell reactions they listed and the consumptive ratios they determined, McCarty, et al. (35) developed equations 9 and 10 which predict the quantity of methanol required and the expected biomass production for a given wastewater composition.

$$C_m = 2.47\ N_o + 1.53\ N_1 + 0.87\ D_o \quad \ldots\ldots\ldots\ldots (9)$$

$$C_b = 0.53\ N_o + 0.32\ N_1 + 0.19\ D_o \quad \ldots\ldots\ldots\ldots (10)$$

where:

C_m = required methanol concentration, mg/l

C_b = biomass production, mg/l

N_o = initial nitrate nitrogen concentration, mg/l

N_1 = initial nitrite nitrogen concentration, mg/l

D_o = initial dissolved oxygen concentration, mg/l

Conflicting theories on the effect of temperature variation on biological denitrification have been presented. Mulbarger (24) in his studies has shown that denitrification varies significantly and nonlinearly with temperature. Mechalas, et al. (38) concluded that denitrification rates respond to temperature changes by the typical Q_{10} rate based on studies at only two temperatures. Dholakia, et al. (39) concluded that temperature effects biological denitrification only slightly, particularly at methanol to nitrate ratios less than optimal. However, from the description of their studies, an excess of denitrifying sludge appeared to be present so that the researchers were possibly measuring variations in some parameter other than the rate of denitrification with temperature. In some recently reported work, Dawson and Murphy (40) report approximately five fold variations in denitrification rates from 5°C (0.013 mg/l NO_3 as N/hr/mg/l MLVSS) to 20°C (0.07 mg/l NO_3 as N/hr/mg/l MLVSS).

Denitrification has been successfully achieved in wastewater treatment operations in two modes: 1.) bed columnar systems and 2.) suspended solids systems.

Denitrification has been performed on filter media using both up flow and down flow techniques. Parkhurst, et al. (41) observed in their Pomona, California studies that denitrification was occurring in their activated carbon columns designed to remove residual organic material and suspended solids from secondary effluents. It was further observed that denitrification improved if methanol was added to the influent stream and that denitrification was not impaired by filter backwashing. St. Amant and McCarty (42) reported on their studies of the San Joaquin Project where waste agricultural ground water is to be placed into the San Francisco Bay system. Their objective was to develop methods to control the discharge of undesirable quantities of nitrates into this Bay system. In their studies, up flow filters were used for biological denitrification with the major variables being the filter media and detention time. They found this to be a reliable process if methanol, serving as a energy source for the denitrifying organisms, was added carefully so as to avoid either over or under dosing of the methanol. They also determined that at 12°C with a one hour detention time, at least 90 percent removal of 20 mg/l of nitrate-nitrogen was achieved using one inch gravel media. Tamblyn and Sword (43) confirmed St. Amant's findings and further found that long term operation without filter backwashing was possible if measurable suspended solids could be tolerated in the effluent. Smith, et al. (44) in recently reported studies, using nitrified wastewater treatment plant effluent, found that by using finer filter media (coarse sand to 3/4 inch stone) denitrification could be achieved in as little as ten minutes. Furthermore, effluent suspended solids were removed by filtration with the only drawback being a daily backwashing requirement using from 1-3 percent of the process effluent.

Barth, et al. (5) utilized a two step organic carbon removal-nitrification process, but also added a third step, denitrification. In this system three separate suspended sludge systems, each with respective settling and recycling facilities, were used. Additional work of this type has been reported by Mulbarger (45). In his studies at Manassas, Virginia a number of different process alternatives for nitrification-denitrification were studied. His results indicated that the three sludge system, as reported by Barth (5), consistently provided the most dependable operation. His explanation for this favorable operation was the use of isolated sludge systems with optimized environmental conditions. He recommended, because of the low synthesis rate of the nitrifying and denitrifying organisms, that capability of wasting solids to both the second and third systems from the first reactor be provided. Aeration after final settling was Mulbarger's recommendation to meet effluent dissolved oxygen requirements because the denitrifying floc was found to break up if pre-sedimentation aeration is practiced. He presented curves of nitrification and denitrification versus temperature, and finally concluded that this three sludge system can be provided at a capital cost within 10 percent of that for a conventional activated sludge treatment plant.

SECTION V

EXPERIMENTAL METHODS

Description of the Pilot Plant

The facility used for this investigation had three major components; pilot, plant, chemical feed and storage building, and laboratory and office trailer. Pictures of this facility are presented in Figures 10 and 11 and the plans prepared for the construction of the pilot plant by Greeley and Hansen Engineers are attached in Appendix A. The pilot plant was built complétly above ground on a 45' x 50' concrete pad located on the grounds of the South Bend Wastewater Treatment Plant, South Bend, Indiana. During most of the experimentation, a flow rate of 45 gpm or 65,000 gpd was maintained. As indicated previously in Figure 1, the pilot plant consisted of a series of three reactor systems, two of which were composed of a reactor and settling tank with sludge recycle capability and the third system has these features with the addition of a flash aerator between the reactor and the settling tank. The three reactors each measured 10' x 10' x 12' high while the settling tanks which were of circular shape with rim flow feeders, each measured 12' in diameter and were 11' high with 6' bottom cones. Curves indicating the hydraulic detention time of the reactors for various influent flows and sludge recirculation rates are shown in Figure 12. The detention times and overflow rates for various flow rates in the settling tanks are shown in Figure 13. All reactors can be considered to be operating in a completely mixed mode (see Section VI).

RETURN SLUDGE FACILITIES

INFLUENT & EFFLUENT LINES

TOP VIEW OF PILOT PLANT

ELEVATION OF PILOT PLANT

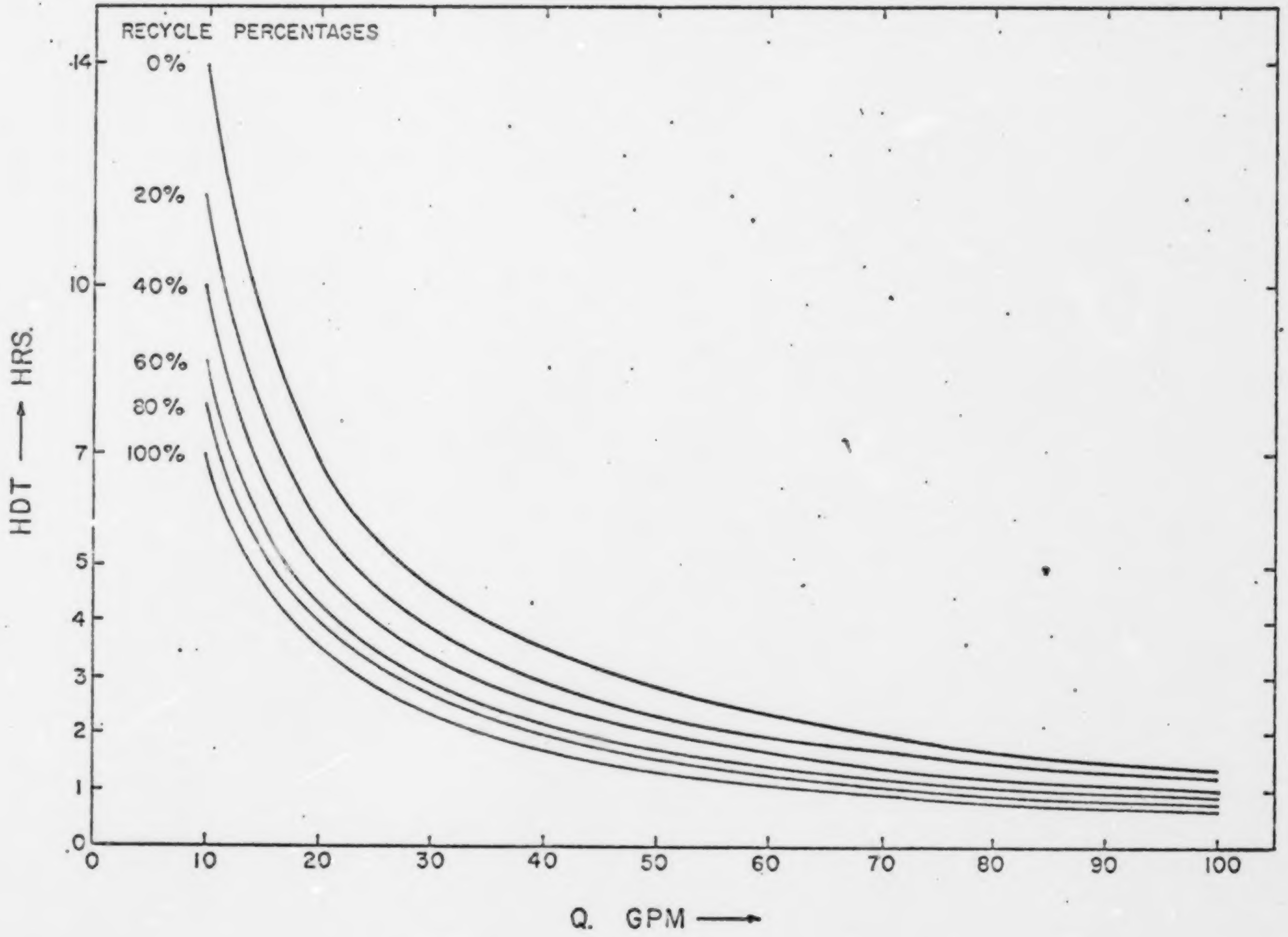


Figure 12: Reactor Hydraulic Detention Times for Various Influent and Sludge Recycle Flow Rates.

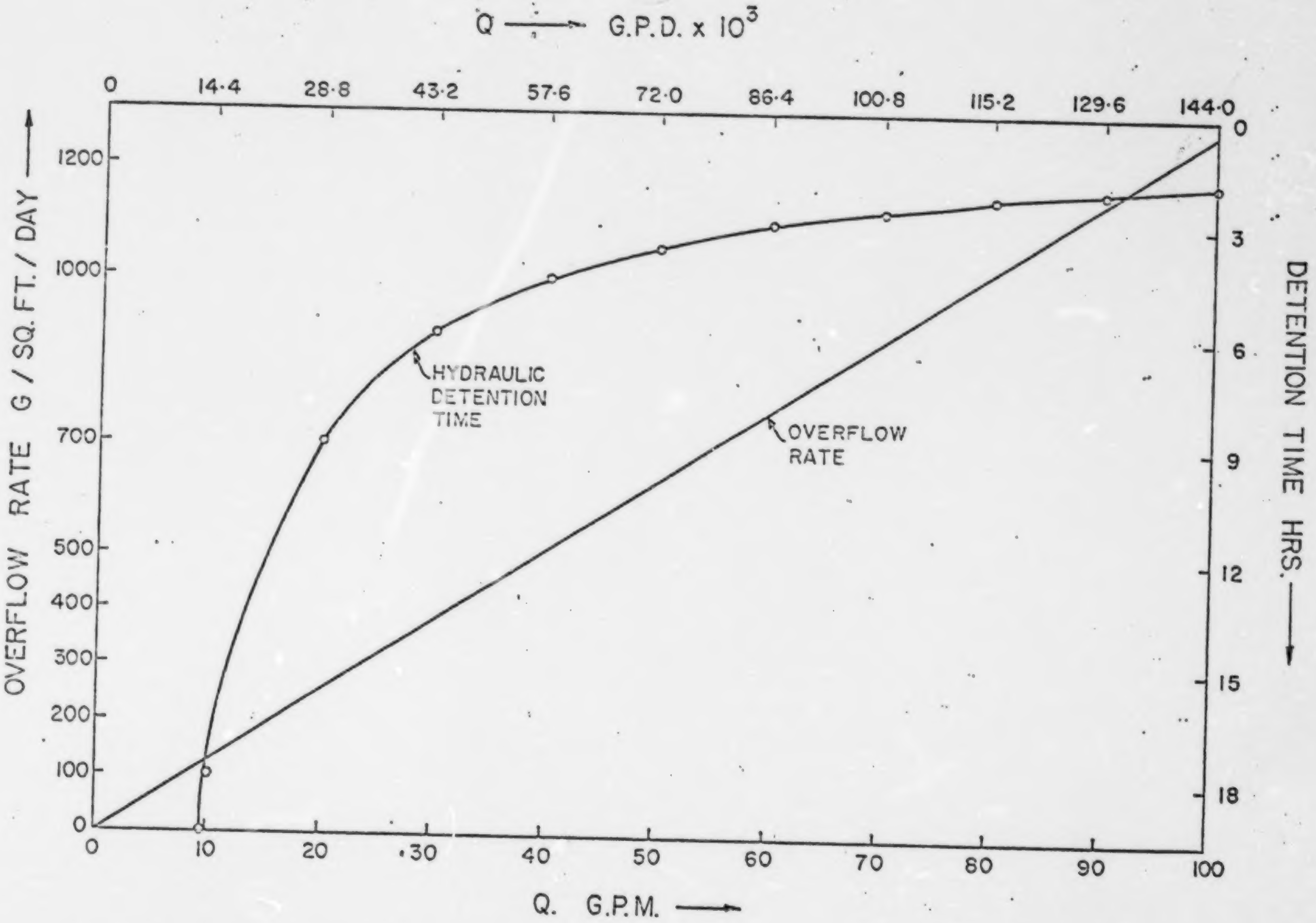


Figure 13: Settling Tank Overflow Rates and Detention Times as a Function of Flow.

Air was supplied to the first two reactors and the flash aerator by a rotary lobe blower (Roots-Connersville Blower) and distributed by Walker Process Co. spargers. Air and sludge recycle flow were measured with orifice plates using flange taps and manometers (BIF Orifice Plates, Manometers, and Venturi Meter). By the use of gate valves on each air flow line, the quantity of air supplied to each location could be accurately controlled. Sludge was recycled by three variable speed centrifugal pumps (Wemco Torque Flow Pumps). Wastewater was pumped to the pilot plant constant head tank from the raw wastewater channel of the South Bend Wastewater Treatment Plant by a submersible centrifugal pump (Wemco). A V-notch weir in the constant head tank provided accurate hydraulic control of pilot plant flow. Excess wastewater was discharged over the V-notch weir directly to the plant drain which discharged into the activated sludge tank of the South Bend Wastewater Treatment Plant. Flow through the pilot plant was measured by a venturi meter (BIF) placed between the constant head tank and the first reactor.

Chemicals, which were stored in the chemical feed and storage building, were mixed into solution form. The alum solution (1 lb alum per gal water) was prepared daily in a 55 gal polyethylene lined drum, and the methanol solution (8 gal methanol to 45 gal water), was prepared every third day. These solutions were pumped by variable capacity diaphragm pumps (BIF) through 1/2 in. PVC pipe to the first and third reactors.

Samples were collected hourly using an automatic sampling system. This system consisted of two time clocks in series that emitted an electrical signal hourly which opened solenoid valves located throughout the pilot plant. The samples which passed through the open valves were collected in ten liter aluminum foil coated containers. The aluminum foil was provided to minimize algal growth in these sample containers. Analyses were performed daily on these 24 hr. composite samples.

Description of Analytical Techniques

Analytical tests on the collected composite samples were, for the most part, performed in the 12' x 24' laboratory trailer located adjacent to the pilot plant. Table 4 provides a listing of the analytical tests performed. These analyses were performed according to Standard Methods (46) unless otherwise indicated. Soluble analyses were performed on wastewater constituents which passed through a Reeve Angel Glass Fiber Filter Pad. In all cases where data were collected, time was allowed for the biological systems to be conditioned and to reach an equilibrium stage of operation. The total phosphate analysis as described in Standard Methods has been reported to yield low results if analyzed samples contain significant organic material (47) (48). Eberhardt and Nesbitt (48) have reported, however, that for wastewater treatment plant effluent samples, the Standard Methods analysis is essentially a total phosphorus result. Therefore, raw wastewater total phosphorus values throughout this study may be slightly low, but effluent concentrations should be accurate in most cases.

TABLE 4

LIST OF ANALYTICAL TESTS PERFORMED AND PROCEDURES FOLLOWED

Analyses	Procedure
Alkalinity[2]	Standard Methods (46)
Aluminum	Eriochrome Cyanide R (49)
Ammonia Nitrogen[1]	Direct Nesslerization (46)
Biochemical Oxygen Demand[2]	Standard Methods (46)
Chlorine, Residual	Standard Methods (46)
Chemical Oxygen Demand[3]	Small Sample Modification (46)
Dissolved Oxygen[4]	YSI DO Probe with Model 54 Meter
Methanol[1]	Antazak and Piotrowski (50)
Nitrate Nitrogen[1]	Hydrazine Reduction (51)
Nitrite Nitrogen[1]	Hydrazine Reduction (51)
Organic Nitrogen[2]	Kjeldahl Digestion (46)
pH[2]	Glass Electrode (46)
Phosphorus[3]	Stannous Chloride (46)
Sludge Volume Index	Standard Method (46)
Temperature[4]	YSI Thermistor with Model 154 Meter
Suspended Solids[2]	Glass Fiber Filters (52)
Volatile Solids[2]	Glass Fiber Filters (52)

[1] soluble analyses only (on glass fiber filter filtrate)
[2] total analyses only (no sample pretreatment)
[3] total and soluble analyses
[4] *in situ*

SECTION VI

EXPERIMENTAL RESULTS

Initial Operation.

Following construction of the Notre Dame-EPA Advanced Wastewater Treatment Pilot Plant, preliminary investigations were concerned with determining the capability and characteristics of the physical plant. Characteristics of interest included; operation of flow measuring equipment and determining required flow measurement calculations, raw wastewater and sludge recycle pumping capability, estimated chemical feed application rates, and the development of standardized laboratory procedures and maintenance schedules.

The hydraulic characteristics of the completely mixed reactor in series with a rim flow sedimentation tank was of considerable interest. Determination of such information as mean hydraulic detention time would indicate how long, on the average, an element of wastewater remains in the system where it is being treated. To determine these hydraulic characteristics, a tracer study was performed, the results of which are presented in Figure 14. These data show that the completely mixed reactor ahead of the sedimentation tank distributes the tracer in decreasing quantities over a period of time as demonstrated by the lack of a sharp modal peak which is characteristic of tracer studies in sedimentation tanks alone. Of the 98 g of fluorescein tracer applied to the first reactor system, 105 g were measured in the effluent of the settling tank for a 107 percent recovery. Wallace (53) has stated that tracer study dye recoveries of from 75 to 110 percent are indicative of a properly performed test. This

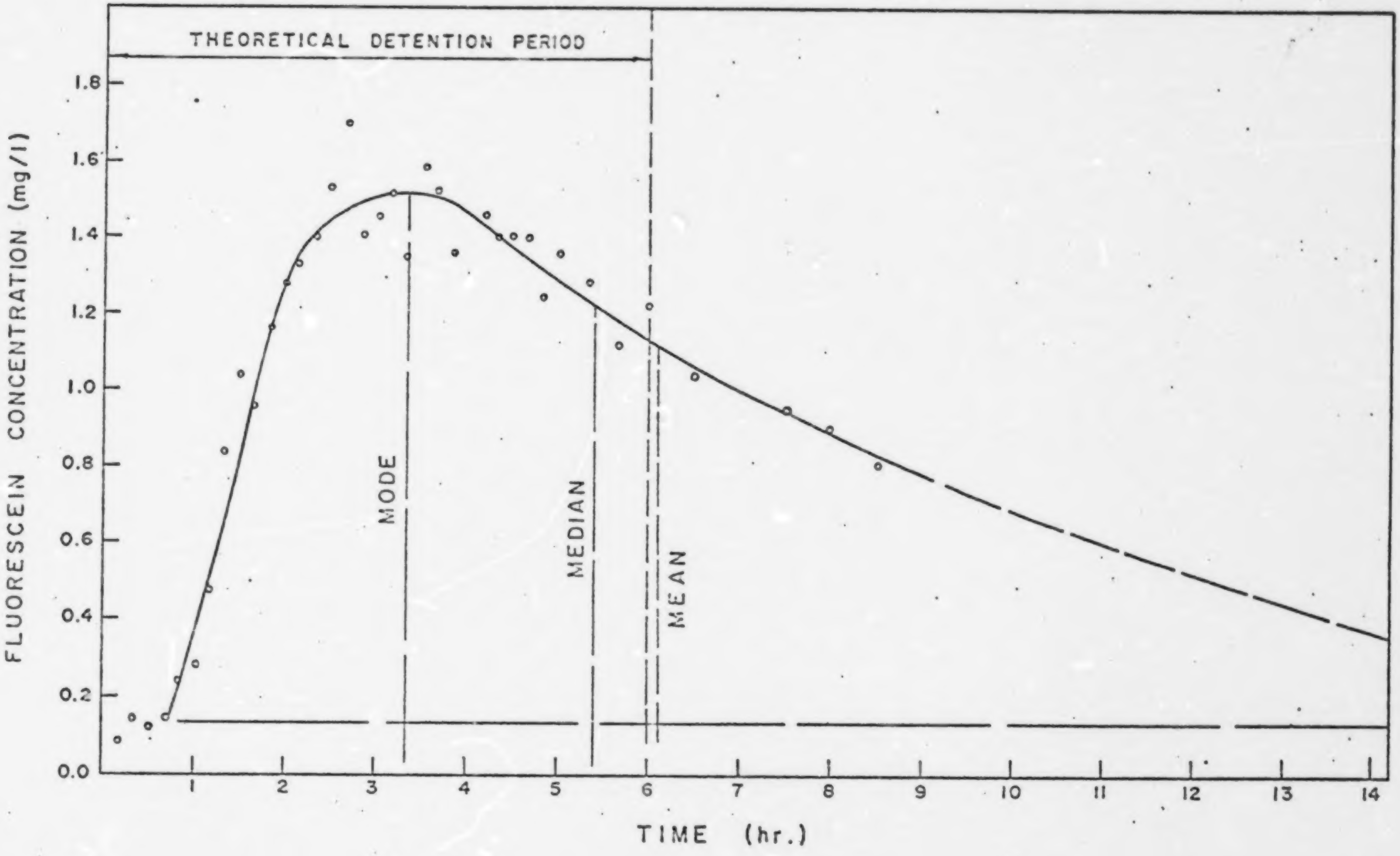


Figure 14: Tracer Study of Reactor-Settling Tank System.

study revealed that there were no significant signs of hydraulic short circuiting through the first reactor-settling tank system and from this it was assumed that similar flow conditions were occurring in reactor systems two and three.

Following the initial start-up, the pilot plant was operated for a one-month period to demonstrate that effective wastewater treatment could be obtained using this biological-chemical treatment scheme on a pilot plant scale. A summary of continuous operational data for May, 1970, with the exception of BOD and total phosphorus data which are results from the month of August is presented in Table 5. A trace of the daily composite value of COD and total inorganic nitrogen is shown in Figure 15. These data are representative of the continuous capability of this combined chemical-biological treatment process with the possible exception of phosphorus removal. Higher phosphorus removal percentages could be accomplished by the addition of more chemical precipitant.

Monthly operational summaries of the pilot plant are presented in Appendix B of this report. These summaries, which include data from April, 1970, through November, 1970, were compiled from more detailed daily records presented in Appendix C.

Continuous Operation

After the operating capability of the pilot plant was established from its performance during the month of May 1970, continuous operation of the pilot plant was begun in June 1970. This operation was continued through the

Table 5: Summary of Initial Operational Data of the Pilot Plant.

Wastewater Parameter	Raw Wastewater	Conventional Effluent	Nitrified Effluent	Denitrified Effluent	Percent Removal
BOD$_5$					96
Average	121	4	3	5	
Range	89-160	1-9	1-5	3-7	
COD					84
Average	304	85	54	55	
Range	180-563	38-107	29-95	36-97	
Suspended Solids					86
Average	159	36	28	22	
Range	74-326	20-57	8-71	10-42	
Ammonia-N					96
Average	6.0	4.3	0.3	0.3	
Range	1.6-10.2	1.9-7.1	0.1-1.2	0.0-1.5	
Nitrite + Nitrate-N					
Average	0.8	0.8	5.7	0.0	
Range	0.3-1.4	0.3-1.3	3.4-10.0	0.0-0.0	
Total Phosphorus					83
Average	4.7	1.1	0.9	0.8	
Range	2.7-6.3	0.4-2.3	0.4-1.6	0.4-1.9	

Note: All values in mg/l

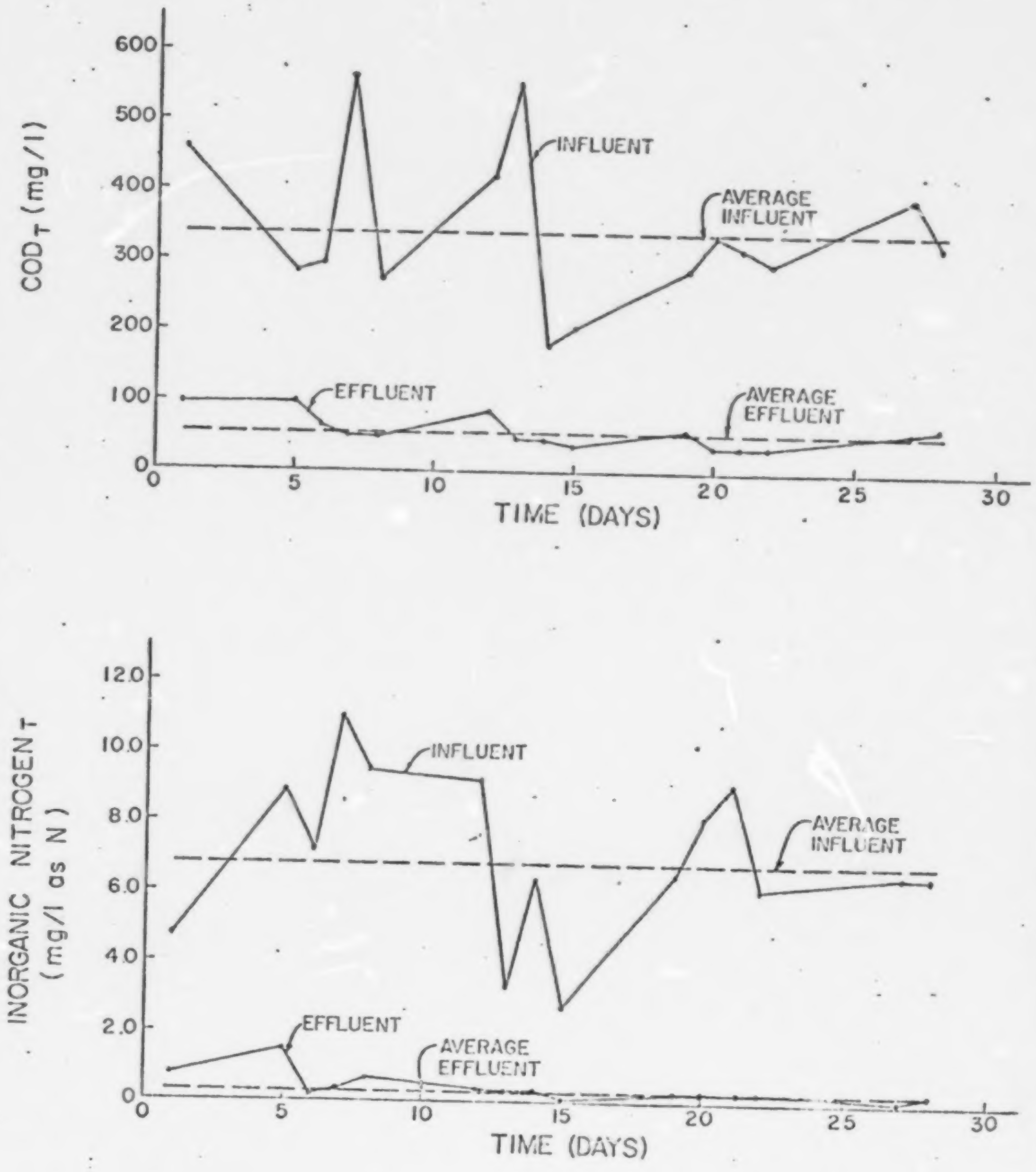


Figure 15: Influent and Effluent Concentrations of COD and Nitrogen for May 1970.

greater part of November 1970 at which time the pilot plant had to be drained because of the onset of freezing temperatures at night. The daily trace of the daily composite influent and effluent values of COD, total inorganic phosphorus and total inorganic nitrogen are shown in Figures 16-19 for the months of June through September 1970, respectively. These illustration were prepared from the daily records of the pilot plant operation (see Appendix C) for these months.

As can be seen from these illustrations, there were significant fluctuations in the influent wastewater quality over this period, but the pilot plant was able to cope with this variable and produce a relatively stable effluent quality. Further observation of these results would tend to indicate that this particular advanced wastewater treatment scheme is quite capable of sustaining shock-type loadings to the different sludge systems. In addition, as will be described subsequently, there were intentional variations in operating conditions and procedures (e. g., MLVSS, chemical additions, etc.) during this period. The average percentage of pollutant removal (and ranges) for this period are shown in Table 6.

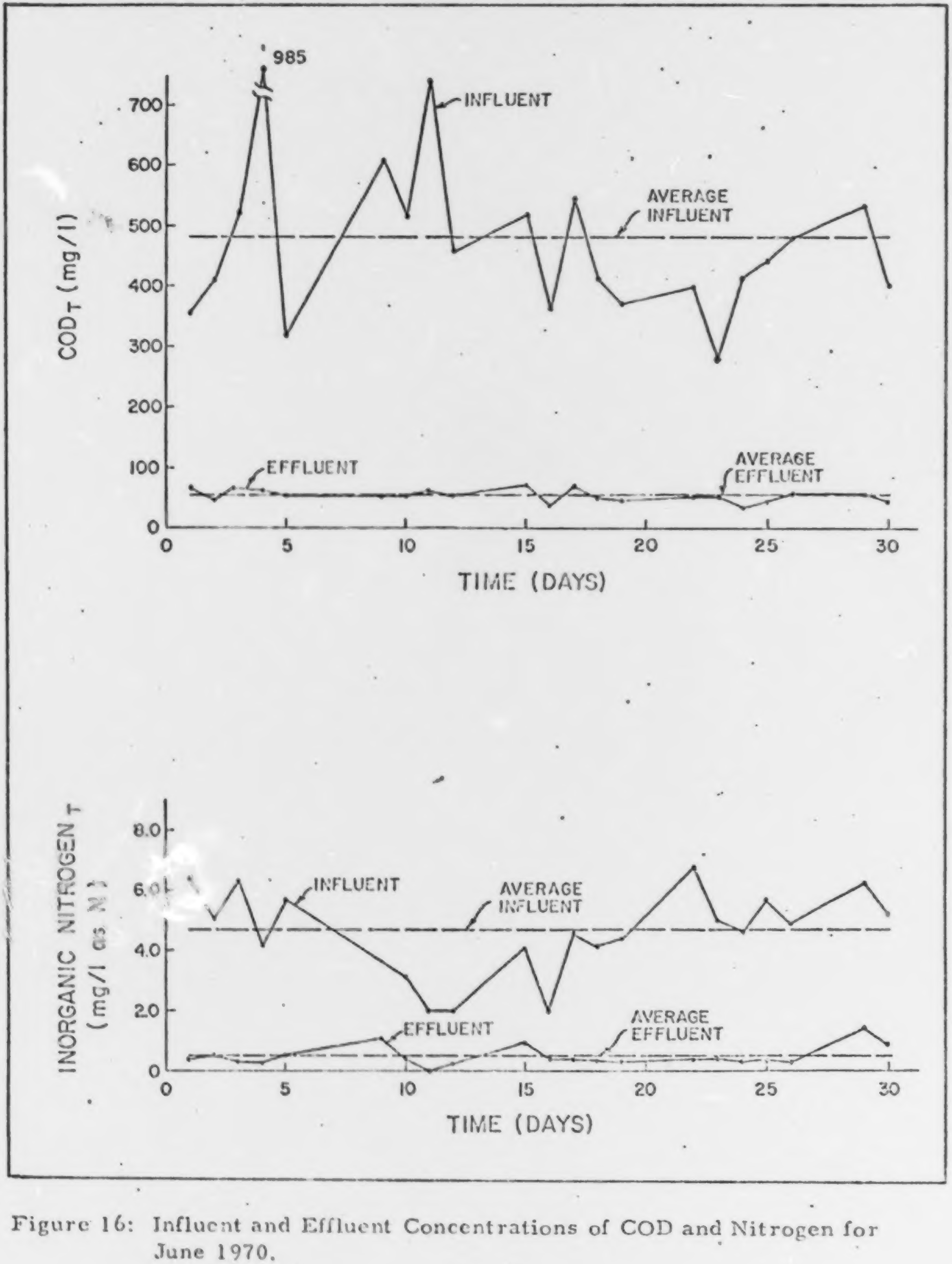


Figure 16: Influent and Effluent Concentrations of COD and Nitrogen for June 1970.

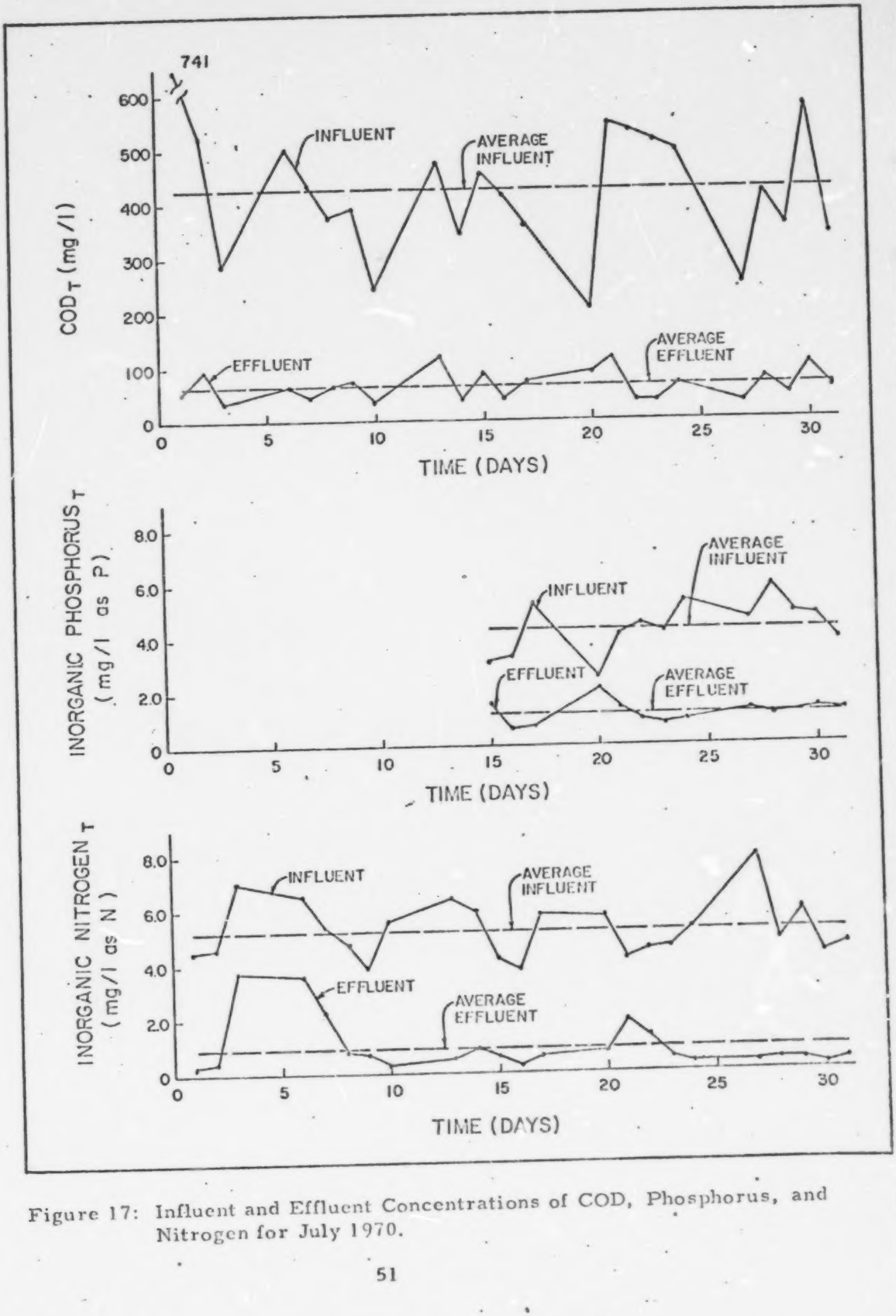


Figure 17: Influent and Effluent Concentrations of COD, Phosphorus, and Nitrogen for July 1970.

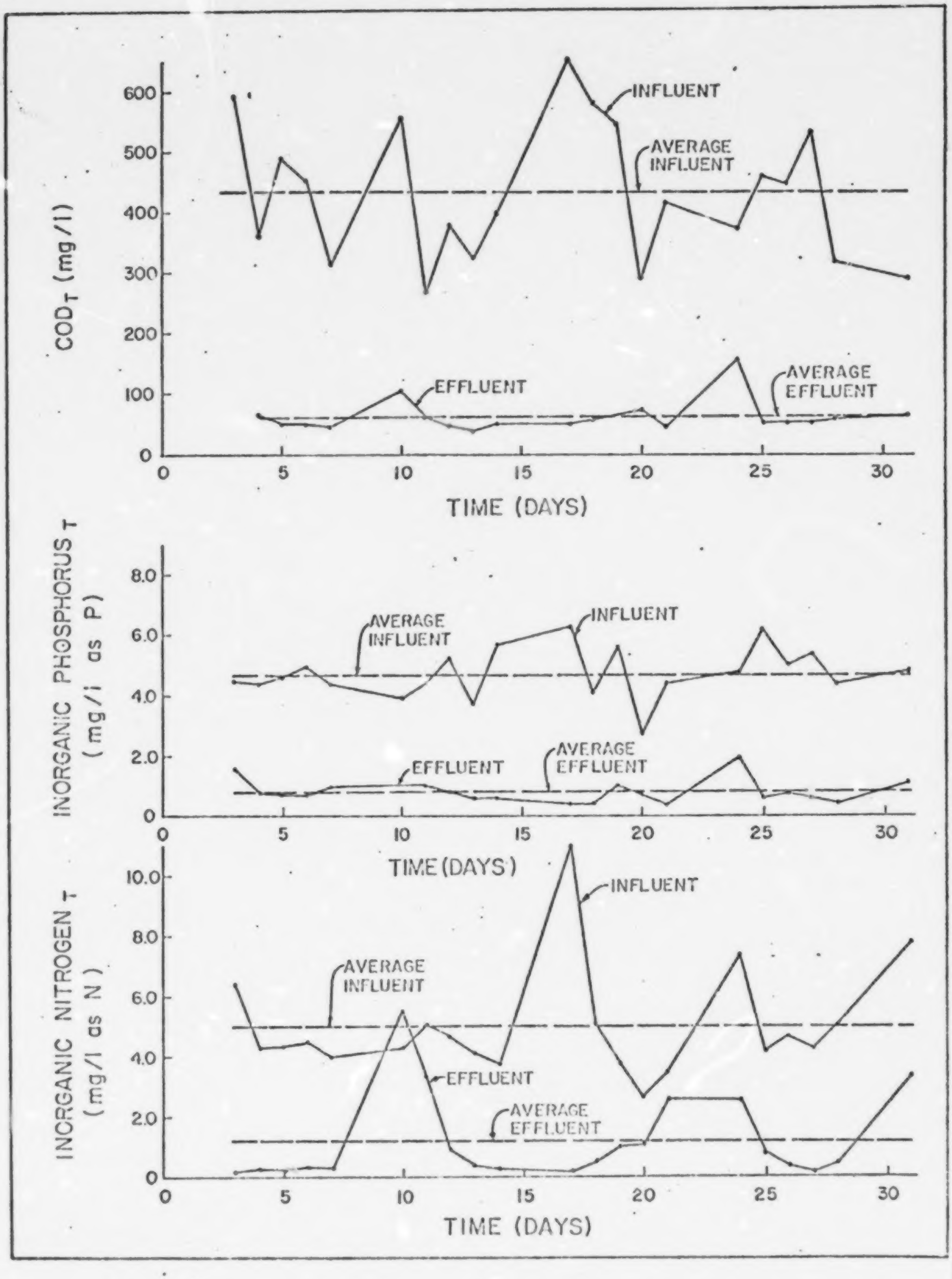


Figure 18: Influent and Effluent Concentrations of COD, Phosphorus, and Nitrogen for August 1970.

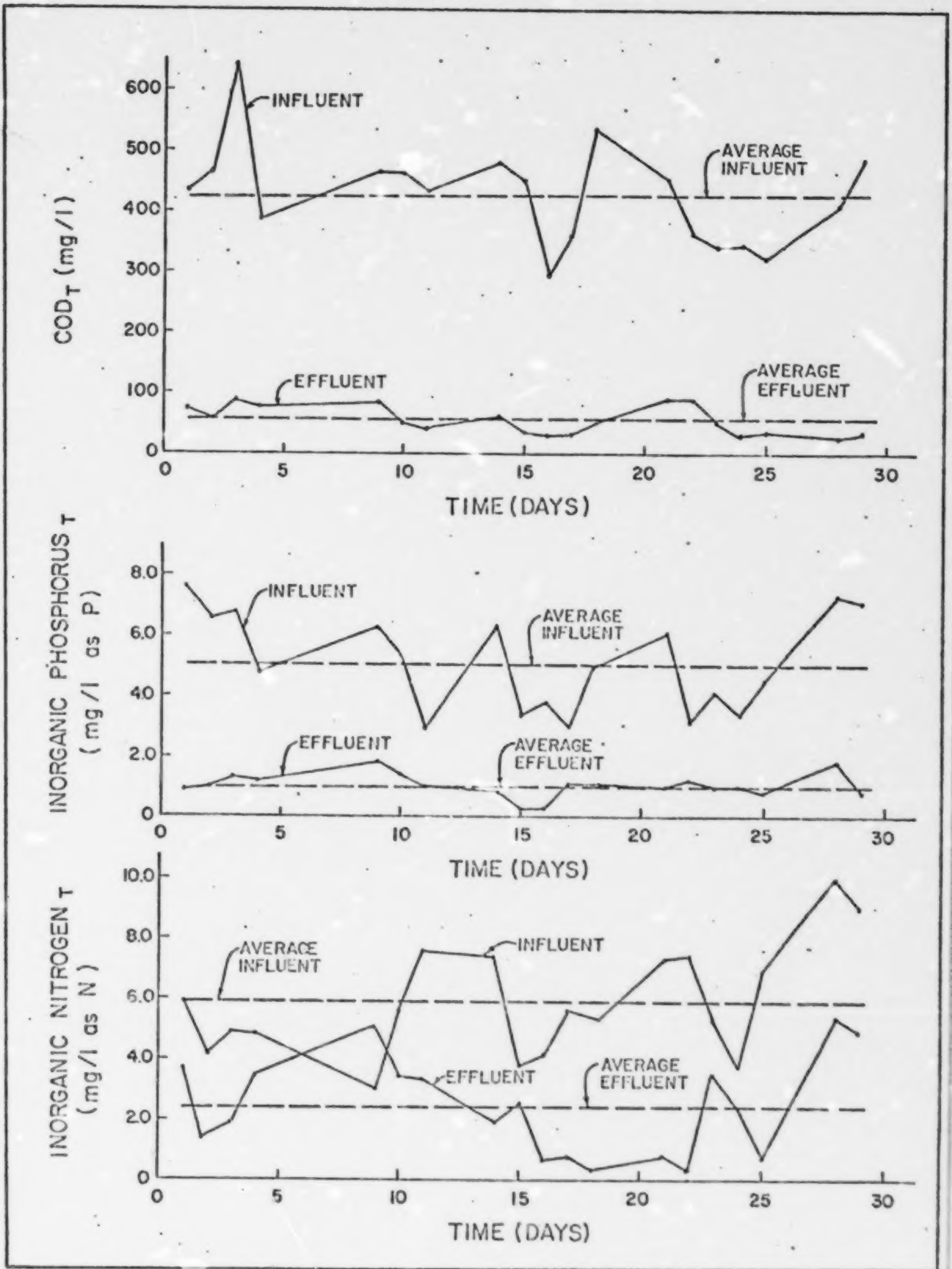


Figure 19: Influent and Effluent Concentrations of COD, Phosphorus, and Nitrogen for September 1970.

Table 6: Average Pollutant Removals over the Period June 1, 1970 - September 30, 1970.

Pollutant	Average Removal (Percent)	Range (Percent)
Chemical Oxygen Demand	87	57 - 94
Total Inorganic Phosphorus	78	14 - 94
Total Inorganic Nitrogen	77	26 - 99

Note: These data include times of poor operation and experimental variations and should not be misconstrued as being representative of the pilot plant's operational capability.

First Reactor Observations (Carbon and Phosphorus Removal)

Suspended Solids Variation. Suspended solids concentrations were varied in Reactor I to determine what effect this parameter had on organic carbon removal. The results, presented in Table 7, reveal that volatile suspended solids were varied over a 400 percent range. These data which are the average of 10 days of operation at each volatile suspended solids level indicate no marked difference between the four groups. There appears to be slightly improved organic removal with increased suspended solids, and flocculation appears best in the 1500 mg/l MLVSS range, but no definite conclusions could be drawn from these results.

Phosphorus Removal. Aluminum to phosphorus ratios were varied throughout the operation of the Pilot Plant. Ratio changes resulted from supplying

Table 7: Effect of Suspended Solids Variations on Sludge System I.

MLSS mg/l	MLVSS mg/l	COD Removal (%)	Suspended Solids Removal (%)
1140	750	84	89
2800	1550	84	94
3275	2050	85	87
5075	3350	86	90

different quantities of Al(III) to the first reactor and by changes that resulted from variation in influent phosphorus concentrations for constant Al(III) feed. Overall variations in aluminum to phosphorus ratio were from 0.58 to 1.66. Figure 20 is a graphical summary of phosphorus removal data presented as residual phosphorus versus aluminum to phosphorus ratio. For comparative purposes, curves for phosphorus removal by Brenner (54) and Grigoropoulos (55) are also presented. Both of these researchers used Al(III) in the alum form for phosphorus precipitation in activated sludge systems. However, Brenner's influent phosphorus concentration averaged about 12 mg/l and Grigoropoulos' was approximately 16 mg/l or from 2 to 3 times the average influent phosphorus concentration to the Notre Dame-EPA Pilot Plant.

Second Reactor Observations (Nitrification)

The primary objective of the nitrification investigation was to empirically determine a nitrification loading factor upon which a process design could be based. Following a two week preparation period during which time sludge concentrations and air flow rates were adjusted, two weeks of data were collected for the determination of a nitrification loading factor. These data are presented in Table 8.

Computational analysis of these data consisted of daily determining the amount of ammonia nitrogen nitrified within the second reactor system and dividing that figure by the quantity of VSS under aeration in that system. As statistical analysis of these data resulted in a mean nitrification loading factor of 0.09 ± 0.03 mg of ammonia nitrogen nitrified per day per mg MLVSS. This factor

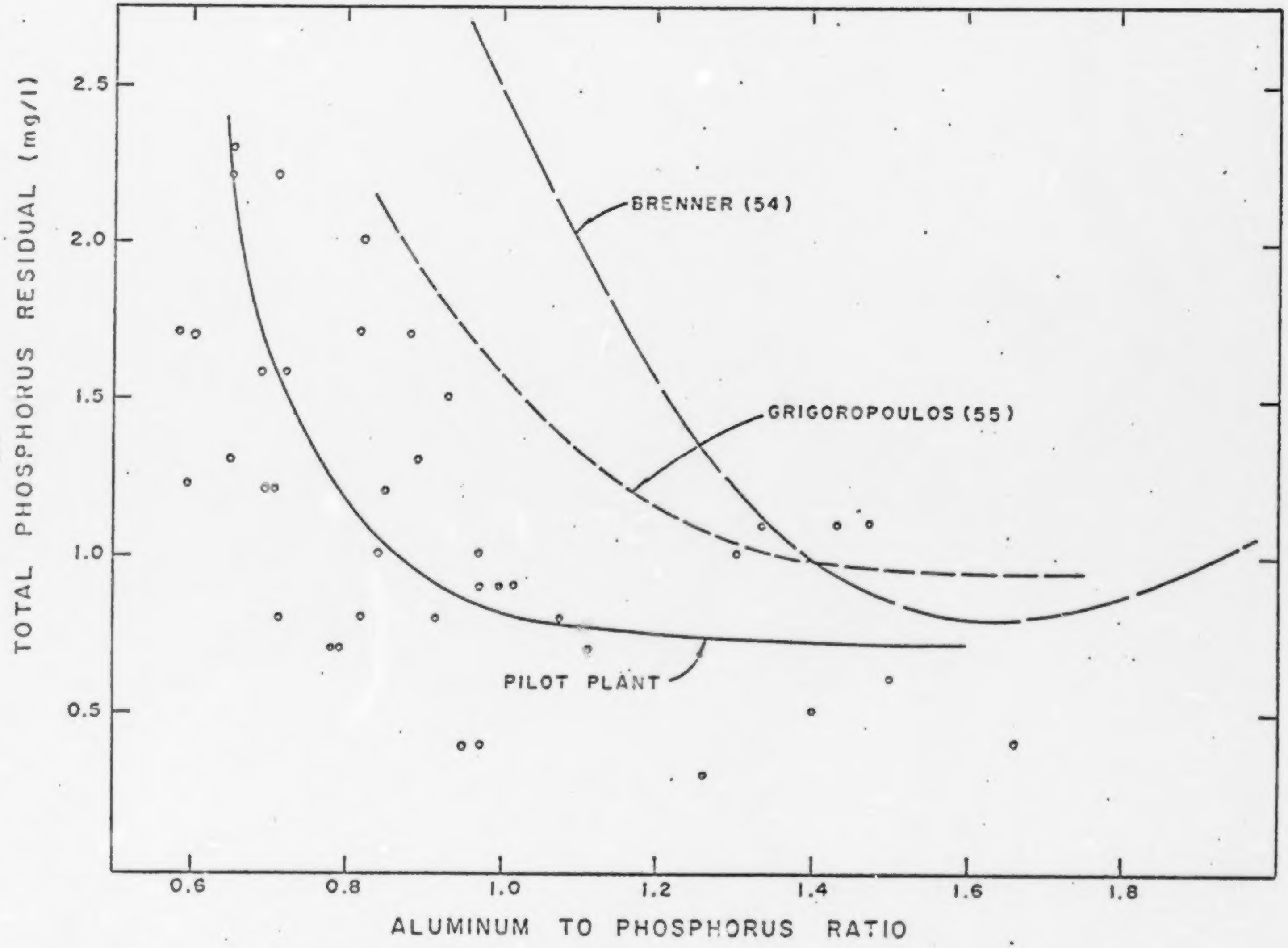


Figure 20: Effects of Aluminum to Phosphorus Ratio (Al/P) on Phosphorus Residual.

Table 8: Determination of Nitrification Loading Factor.

Day	Ammonia-Nitrogen (as N)			Q gpm	MLVSS R II mg/l	N*
	S I Effluent mg/l	S II Effluent mg/l	Removed (S II - S I) mg/l			
1	1.2	0.3	0.8	45	78	0.12
2	1.0	0.7	0.3	45	30	0.10
3	5.0	4.5	0.5	45	116	0.04
4	6.7	4.4	2.2	45	325	0.07
5	6.6	4.2	1.3	45	244	0.10
6	7.3	3.8	2.7	45	308	0.15
7	7.1	2.9	4.1	45	776	0.05

$$*N = \frac{\text{mg } NH_3 - N \text{ Nitrified/Day}}{\text{mg MLVSS}} = \frac{\text{mg/l } NH_3 - N \text{ Nitrified} \times 65{,}000 \text{ gal}}{\text{mg/l MLVSS} \times 6{,}500 \text{ gal}}$$

was developed at an average temperature of 18°C and pH of 7.5.

Third Reactor Observations (Denitrification)

A loading factor for the denitrification system was developed in a manner similar to that of the nitrification system. Following an adjustment period, daily measurements were made of the decrease in the nitrite and nitrate forms of nitrogen as the wastewater passed through the third sludge system. In addition to these changes, influent dissolved oxygen, pH, temperature, methanol supply and MLVSS were monitored. Methanol was continously supplied to the third system at a slight excess based on average influent nitrate values. In situations where high influent nitrogen concentrations occurred, it was possible for methanol to be limiting. Therefore, daily checks, using McCarty's (35) predictive formula, were made to determine if methanol was a limiting parameter during these studies. Data collected over a three week period are presented in Table 9. During this three week period, five days' data were lost due to possible methanol limitations and due to a short period of exceptionally high influent ammonia (approximately 8 times normal loading) which temporarily upset the pilot plant operation. The computational analysis of these data consisted of determining daily the quantity of nitrite and nitrate nitrogen denitrified within the third reactor system and dividing that figure by the concentration of VSS in the third reactor. Statistical analysis of these daily computed factors resulted in a mean denitrification loading factor of 0.06 ± 0.02 mg of nitrite and nitrate nitrogen denitrified per day per mg MLVSS. The studies conducted to develop the denitrification

Table 9: Determination of the Denitrification Loading Factor.

Day	Nitrate + Nitrite-N			DO S II mg/l	Q gpm	MLVSS R III mg/l	D*
	S II Effluent mg/l	S III Effluent mg/l	Removed (S III-S II) mg/l				
1	5.8	2.2	3.6	5.4	50	610	0.07
2	7.5	4.7	2.8	7.6	48	810	0.04
3	7.1	1.6	5.5	5.6	46	704	0.09
4	8.8	5.7	3.1	6.2	48	700	0.05
5	9.0	7.2	1.8	5.9	46	710	0.03
6	8.2	6.4	1.8	6.6	50	724	0.03
7	7.5	4.9	2.6	5.3	50	740	0.04
8	5.3	1.3	4.0	6.2	53	736	0.07
9	10.3	3.5	6.8	2.1	52	1172	0.08
10	9.0	3.3	5.7	4.1	52	1092	0.07

$$^{*}D = \frac{\text{mg } (NO_2 + NO_3 - N) \text{ Denitrified/Day}}{\text{mg MLVSS}} = \frac{\text{mg/l } (NO_2 + NO_3 - N) \text{ Denitrified x 65,000 gal}}{\text{mg/l MLVSS x 5,700 gal}}$$

loading factor were performed at an average reactor temperature of 17°C and pH of 7.6.

In order to determine the validity of the pilot plant denitrification loading factor, laboratory studies were conducted in an attempt to reproduce the field results. In two separate simultaneous reactor studies using acclimated activated sludge at temperature and pH conditions similar to those in the pilot plant, denitrification rates almost identical to that determined in the pilot plant studies were obtained. These data are presented in Figure 21 along with a line representing the field determined denitrification rate for comparison.

Ancillary Studies. Suspended solids in the pilot plant final effluent were consistently high and tests were conducted in an attempt to improve this effluent parameter. These tests took the form of variation in air flow to the flash aerator and laboratory studies to determine the effect of flocculant addition to a simulated flash aerator.

The air flow variation study, summarized in Table 10, demonstrated that the effluent suspended solids concentrations were not significantly improved by varying the aeration rates in the flash aerator. These air flow rates were maintained for two-week periods at approximately constant MLSS concentration.

In another attempt to minimize suspended solids in the final effluent, laboratory studies were conducted to determine the effect of flocculant addition to a reactor which simulated chemical addition to the flash aerator in the third

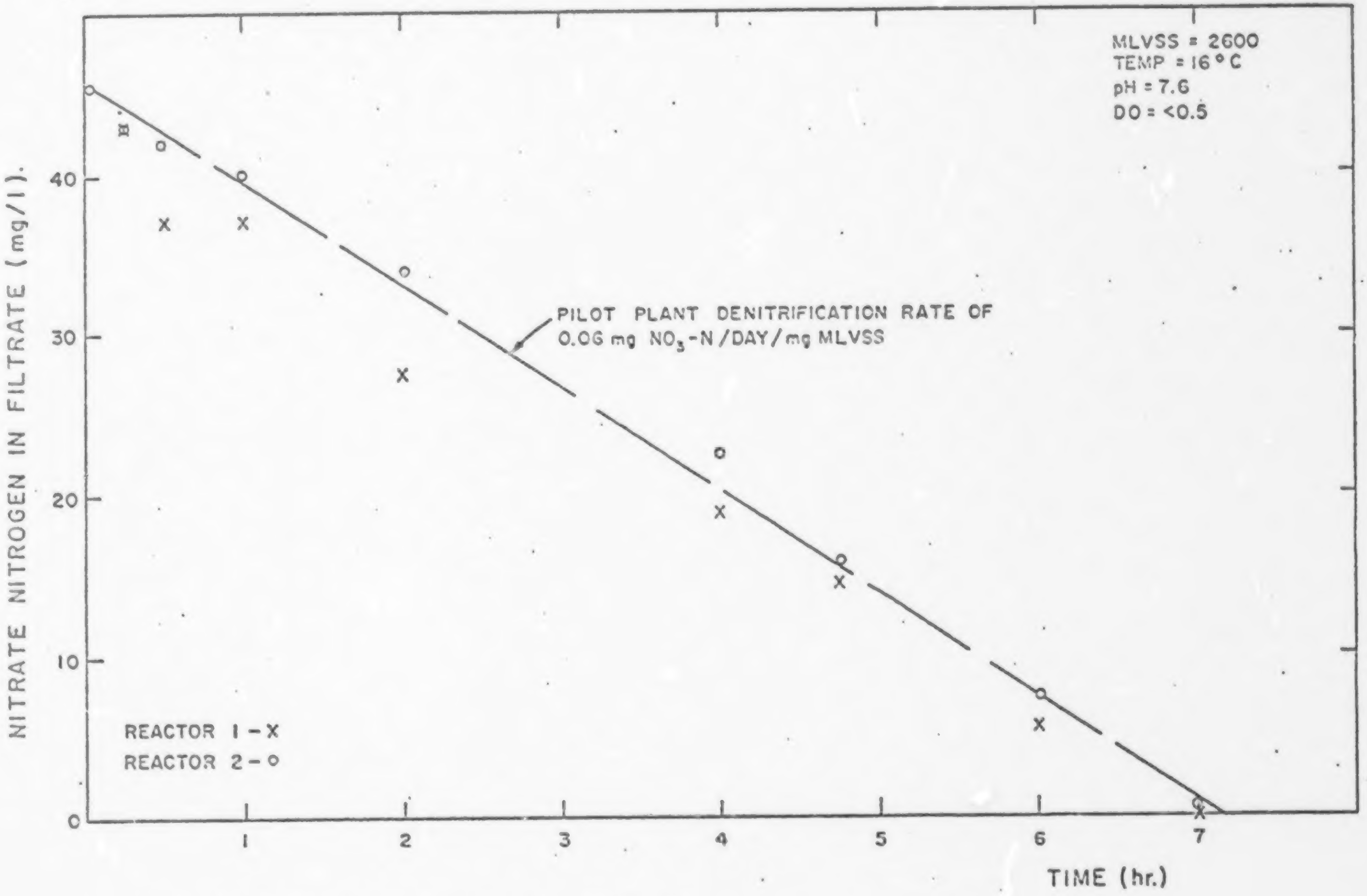


Figure 21: Laboratory Denitrification Study.

Table 10: Effect of Air Flow Variations in the Flash Aerator.

Air Supplied ft^3 /gal	S III Dissolved Oxygen mg/l	S III MLSS mg/l
0.25	0.6	34
0.40	0.7	37
0.65	2.3	35

sludge system. All of the synthetic organic flocculants studied improved the suspended solids removal, but not one reduced the suspended solids to less than 10 mg/l from initial concentrations of 30-40 mg/l. Total phosphorus removal improved due to synthetic flocculant addition, but only in proportion to suspended solids removed.

The flocculation curves presented in Figure 22 demonstrate typical flocculation behavior with areas of efficient flocculation and redispersion. Data for the cationic organic flocculant presented in Figure 23A demonstrates possible initial electrostatic repulsion with subsequent improved flocculation. The alum study presented in Figure 23B demonstrates expected behavior with the exception of one point at 1 mg/l Al(III). The minimum total phosphorus concentration that was obtained with the synthetic organic flocculants was 0.65 mg/l. Al(III) addition did result in suspended solids concentrations below 10 mg/l and total phosphorus concentrations as low as 0.2 mg/l, but these results are influenced by the fact that the initial suspended solids level at the time of the study was only 20 mg/l.

Chlorination of wastewater treatment plant effluent to kill mircoroganisms, including pathogens, is becoming a governmentally required practice. It is common knowledge that chlorine reacts with ammonia to form chloramines and that chloramines have poorer bactericidal capacity as compared to hypochlorous acid. Since domestic wastewater contains significant quantities of ammonia nitrogen, oxidation of this chemical species prior to chlorination would definitely improve the wastewater disinfecting capability for a given quantity of applied chlorine.

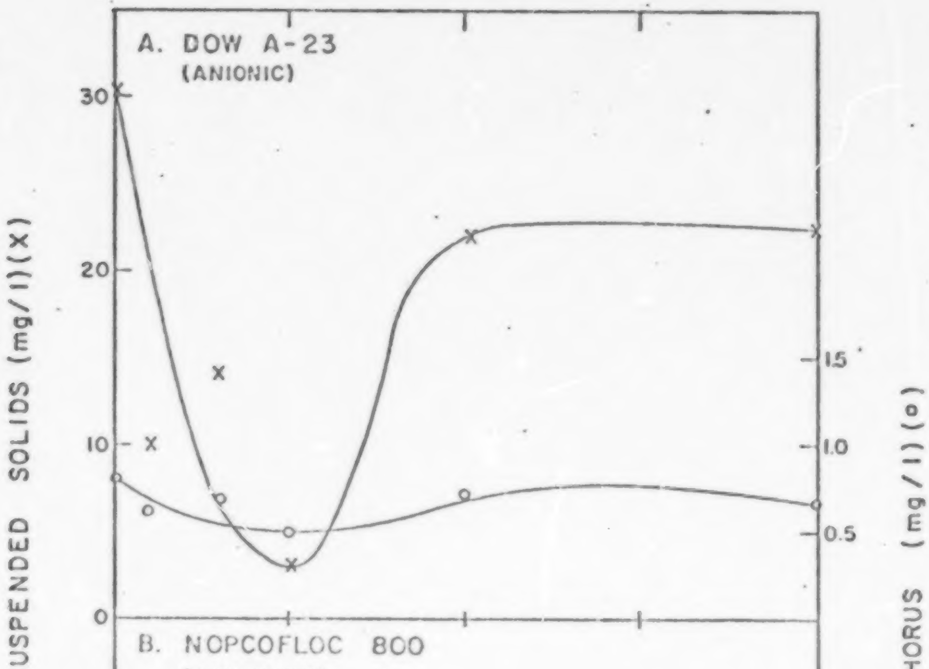


Figure 22: Effect of Synthetic Organic Polyelectrolytes (Cationic and Non-Ionic) on Final Effluent Quality.

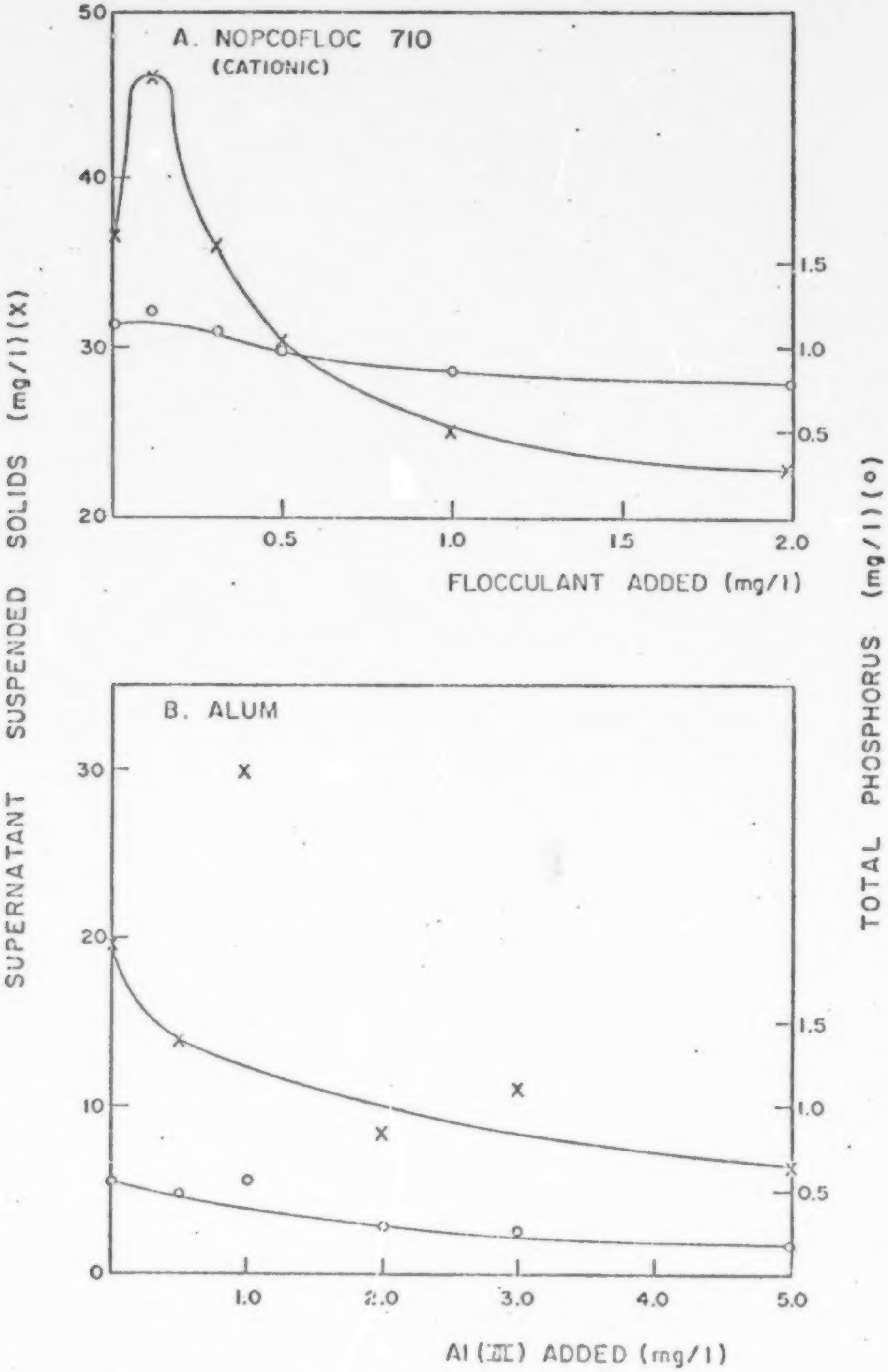


Figure 23: Effect of Cationic Polyelectrolytes and Alum on Final Effluent Quality.

Chlorine demand curves for the South Bend Treatment Plant effluent and the Notre Dame-EPA Pilot Plant effluent are presented in Figure 24. Other investigators (56) have reported that for each mg of ammonia nitrogen present, between 8 and 9 mg of chlorine (by weight) are required to achieve the chlorination break point, after which chlorine will exist as hypocholorous acid. Investigation of Figure 24 reveals that break points were achieved at approximately similar values.

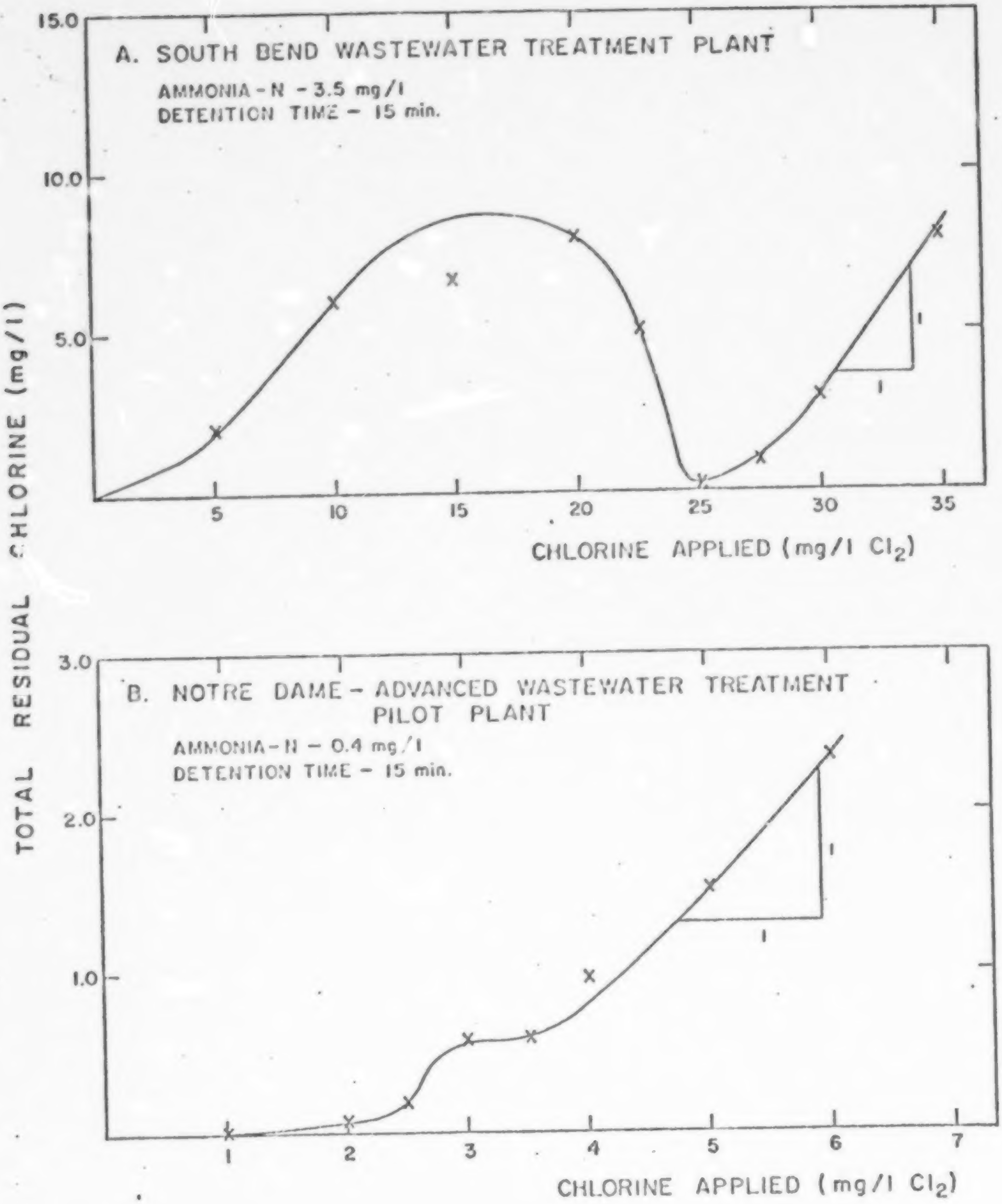


Figure 24: Effluent Chlorination Studies.

SECTION VII

DISCUSSION OF RESULTS

Initial Operation

The initial study with the pilot plant was to determine the hydraulic characteristics of the completely mixed biological reactor in series with a rim flow sedimentation tank. When a quantity of tracer is placed into an ideally complete mixed reactor under constant flow conditions, effluent tracer concentrations will initially be high (equal to the quantity of tracer evenly distributed throughout the reactor) and will exponentially decrease with time. The initially high tracer concentration will be immediately discharged to the first sedimentation tank. If tracer measurements are made on the sedimentation tank effluent, the mode of these measurements would therefore be the modal distribution characteristic for the sedimentation tank. The decrease in concentration from the mode would then demonstrate the exponentail release of tracer from the reactor.

During the actual test, some finite time is required for the fluorescein placed in the first reactor to become uniformly mixed and for this high concentration to begin entering the first sedimentation tank. The measured 3.3 hour modal peak minus some time for complete mixing (about 20 minutes) demonstrates extremely good sedimentation tank operation compared to a theoretical detention time of 3.3 hours. Furthermore, the mean flow through time of 6.1 hours for the reactor-sedimentation tank system is very close to the theoretical detention time of 6.0 hours.

This indicates, on the average, that the wastewater flow is exposed to the treatment process for a period closely approximating the theoretically predicted residence time. The characteristic of the completely mixed reactors to immediately distribute high wastewater concentrations throughout the reactor and to the remaining processes in decreasing concentrations would minimize the possibility of toxic substances interfering with wastewater treatment.

One objective of this research project was to determine the continuous capability of this biological-chemical treatment scheme on a pilot plant scale. The data presented in Table 5 are believed to represent this continuous capability. All of the data presented in Table 5 are based on analysis of daily composite samples for a one month period on a 5 day per week basis. The exception to this are the BOD_5 values which were obtained weekly. The Pilot Plant consistently provided very good organic carbon and nitrogen removals, and phosphorus could be removed to any desired level, down to approximately 1 mg/l, by varying the quantity of alum applied. Effluent suspended solids was the one quality parameter that did not meet expectations.

In reviewing the daily and monthly operational summaries as presented in Appendices B and C, it is important to remember that much of the data presented was obtained during periods when the sludge systems were being manipulated to determine specific information, e.g., design loading factors. During these periods, occasionally poor operation resulted which should not be misconstrued as being representative of the pilot plant's operational capability.

Organic Carbon and Phosphorus Removal

Organic Carbon as measured by the BOD_5 and COD analyses was one of the pollutant removal objectives of this investigation. The results presented in Table 5 demonstrate that both BOD_5 and COD are continuously removed to low residual levels. Table 7 summarizes a study directed at demonstrating the effect of Reactor I suspended solids variation on organic carbon removal. MLSS concentrations were maintained at four different levels spanning the pilot plant capability for 10 day periods. BOD_5 to MLSS loadings for these four phases were 0.87, 0.41, 0.32, and 0.20. Only slightly improved organic removal resulted from the increase of the MLSS concentrations, and suspended solids removal appeared best in the 1550 mg/l MLVSS range, at a BOD to MLSS ratio of 0.41. This ratio closely approximated the recommended conventional activated sludge loading of 0.5 lb. BOD per lb. MLSS per day. Wuhrmann (18) has reported that organic loadings in the range studied do not result in significant variations in BOD removal. His studies revealed that an activated sludge system does not demonstrate a significant reduction in BOD removal efficiency until an organic loading of 2 lb. or more of BOD per lb. MLSS is attained.

Aluminum in the form of alum was the precipitant used for phosphorus removal in the pilot plant facility. Influent phosphorus concentrations along with aluminum to phosphorus ratios have a significant effect on phosphorus removal. It is generally accepted that for a constant influent phosphorus concentration, percent phosphorus removal increases with increasing aluminum to phosphorus ratio, and that for a constant aluminum to phosphorus ratio, percent removal increases with increasing influent phosphorus concentration.

Grigoropoulos et al., (55) found that the optimum aluminum to phosphorus ratio for phosphorus removal using alum was approximately 1.3/1. (They considered optimum to be negligible additional phosphorus removal with increased doses of alum.) This can be seen graphically be inspection of Figure 20. The results of the pilot plant study demonstrate that the optimum aluminum to phosphorus ratio would be approximately 1.1/1. It appears that for lower influent phosphorus concentrations, less total aluminum addition is required for optimal removal.

Stumm (57) has reported on the solubility of aluminum phosphate in aqueous systems. His results indicate that there is considerable variation in the solubility of aluminum phosphate with pH. Precipitation of aluminum phosphate in combined chemical-biological systems frequently results in phosphate solubilities that differ from those presented by Stumm. Two possible explanations for these observations have been presented by a recent AWWA Task Group on the chemistry of nitrogen and phosphorus in water (58). Amorphous aluminum phosphate precipitates may form which are not defined by solubility products, or isomorphic replacement may occur. Isomorphic replacement could be considered as the phosphate entering an aluminum oxide or hydroxide crystal at an aluminum to phosphate ratio of something other than 1 to 1. Other possible explanations might include; precipitation at a pH or temperature different than that used by Stumm, the presence of complexing agents in wastewater, and the presence of extraneous ions that interface in the precipitation reaction.

Nitrification

The development of a nitrification loading factor that could be used to design a nitrifying sludge system was another objective of this research. The nitrification loading factor developed for the pilot plant was 0.09 ± 0.~~0~~03 mg of ammonia nitrogen nitrified per day per mg MLVSS at an average temperature of 18°C and pH of 7.5. This compares well with the data reported by Wild, et al. (22) (see Figure 9) and Mulbarger (24), using similar study techniques and operating conditions.

Temperature and pH have been reported to influence nitrification (see Figure 9). Both Wild, et al. (22) and Mulbarger (24) presented curves for the effect of temperature on nitrification. Downing (31) has reported that the growth constant for Nitrosomonas doubles for every 7°C change in temperature. Downing continued by stating that pH affected nitrification only in the 6.0 to 7.2 range with little affect in the 7.2 to 8.0 range.

It is significant to note that the MLVSS in the nitrifying reactor actually will contain a very small fraction of nitrifiers --- the remainder of the cells being heterotrophic in nature. This can be observed from a consideration of the basic balance equation for biomass in the reactor:

[Biomass Produced/day] = [Biomass Added/day] + [Biomass Synthesized/day]
- [Biomass Destroyed/day] - [Biomass Leaving System/day] .... (11)

Neglecting the influent and effluent biomass quantities, equation 11 reduces to:

[Biomass Produced/day] = [Biomass Synthesized/day]
- [Biomass Destroyed/day] .... (12)

where

[Biomass Synthesized/day] = $a[S_r\ (8.34)\,Q]$ .... (13)
(lbs/day)

and

a = coefficient of synthesis - dimensionless

S_r = quantity of substrate removed (i.e., ΔBOD_5 or ΔNH_4-N) - mg/l

Q = wastewater flow - MGD

[Biomass Destroyed/day] = $b\ (MLVSS)(8.34) \cdot HDT \cdot \frac{Q}{24}$ ...... (14)
(lbs/day)

b = coefficient of endogenous respiration - days^{-1}

MLVSS = mixed liquor volatile suspended solids - mg/l

HDT = hydraulic detention time - hours

Q = wastewater flow - MGD

As an illustration assume the following conditions for a nitrification reactor designed to follow a conventional secondary wastewater treatment system treating a domestic wastewater:

Q = 1 MGD

$\Delta NH_3 \cdot N$ = 20 mg/l as N

ΔBOD_5 = 20 mg/l

HDT = 2 hours

MLVSS = 1500 mg/l

thus:

Biomass Produced/day

a. Autotrophic Synthesis (use Downing's coefficient of synthesis, $a = 0.05$)

$$a[S_r(8.34)\,Q] = 0.05\,[(20)(8.34)(1.0)] = 8.3 \text{ lbs/day}$$

b. Heterotrophic Synthesis (use typical coefficient of synthesis, for domestic wastewater; $a = 0.5$)

$$a[S_r(8.34)\,Q] = 0.5\,[(20)(8.34)(1.0)] = 83.4 \text{ lbs/day}$$

Total Biomass Synthesized = 91.7 lbs/day

c. Endogenous Respiration (use typical coefficient of endogenous respiration for heterotrophic, $b = 0.06 \text{ days}^{-1}$)

$$b\left[\text{MLVSS}\,(8.34)\,\text{HDT} \cdot \frac{Q}{24}\right] = 0.06\,[1500\,(8.34)(2)(1.0/24)]$$

$$= 62.6 \text{ lbs/day}$$

Total Biomass Destroyed = 62.6 lbs/day

Resultant Solids = 29.1 lbs/day

Under these conditions it will be observed that the MLVSS will be approximately 91 percent heterotrophic. A number of other rather significant observations regarding nitrification can be observed from such solids balance considerations.

Since the nitrifying organisms inherently exhibit low rates of microbial synthesis a large pool of excess biomass is seldom available for recycle of biological solids. Actually, as the equations indicate, it will be very difficult to maintain an appreciable level of biological solids in the reactor. Hence, the consequences of arbitrarily attempting to overdesign a nitrification system are readily apparent.

1. arbitrary extension of the HDT will result in appreciable biomass destruction by endogenous respiration with a possibility of reducing the MLVSS below the desired level, and
2. arbitrary increase of MLVSS can not be achieved because an excess pool of biomass will seldom be available to recycle from.

Another point which has frequently been reported with respect to biological nitrification studies of this nature has been the relatively poor settleability of these microorganisms. As can be observed from the data, poor settling characteristics were never really observed in the operation of this nitrification system. A possible explanation may lie in the high fraction of heterotrophic microorganisms present in the biomass. Although no supporting laboratory studies were performed, the same polymeric surface coverage relationships as described in Section IV should govern the extent of biological flocculation in a nitrification system. In this regard a food (or substrate) to microorganism ratio would control the extent of flocculation. This ratio can be defined as:

$$F/M = \frac{(NH_4 \cdot N)_{eff}}{MLVSS \times 10^{-3}} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (15)$$

where $(NH_4 \cdot N)_{eff}$ = concentration of ammonia nitrogen (as N) in the reactor effluent.

A typical F/M for the nitrification system was $\leq$ 0.5.

It will be noted that for biological solids relationships such as those calculated above, a small concentration of biological solids in the effluent can appreciably effect the solids balance in the system. An operational parameter which considers the ratio of the total biological solids under air to the biological solids lost from the system is the solids retention time (SRT):

$$\text{SRT} = \frac{\text{total weight of solids under air}}{\text{total weight of solids leaving system/day}} \quad \ldots\ldots\ldots\ldots (17)$$

In view of the biological solids considerations presented above indicating that a biological nitrification system will tend basically to be a solids destruction system, rather than a solids producing system, the most significant amount of solids wasting will generally occur in the clarifier effluent. Wasting of excess biological solids should seldom be required.

Values of solids retention time for the nitrification system can be calculated from daily operational data included in Appendix C. Typical values of MLVSS during the study ranged from approximately 1000 - 3000 mg/l with hydraulic detention times somewhat less than three hours. Thus, disregarding any intentional sludge wasting, the SRT can be calculated from

$$\text{SRT} = \frac{\text{MLVSS}\ (8.34)\ (\text{HDT}/24)\ Q}{(\text{VSS})_{eff}\ (8.34)\ Q} \quad \ldots\ldots\ldots\ldots\ldots\ldots (18)$$

or

$$SRT = \frac{(HDT)}{(24)} \frac{(MLVSS)}{(VSS)_{eff}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (19)$$

which gives values of SRT in the range of 5 - 20 days for this system with an average more in the range of 10 - 15 days.

Due to the inherent sensitivity of this process to environmental changes such as temperature and the impact that both overdesign (i.e., large safety factors) and overloading (i.e., excess ammonia loads) can have on this process, it becomes apparent that nitrification can not be designed to perform effectively over a broad range of operating conditions. Rather the process should be designed to meet the average conditions anticipated with the knowledge that auxiliary treatment units will have to be added (or deleted) in order to continuously maintain a highly nitrified effluent.

Denitrification

A denitrification loading factor of 0.06 ± 0.02 mg of nitrate and nitrite nitrogen denitrified per day per mg MLVSS was determined for the third sludge system of the pilot plant at a temperature of 17°C and pH of 7.6. Using this loading factor, a treatment system could be designed to remove oxidized nitrogen forms from wastewater streams. During this investigative development methanol was used as the organic carbon supplement in these studies. Mulbarger (24) performed similar denitrification studies and determined a loading factor of approximately 0.28 ± 0.12 mg of oxidized nitrogen removed per day per mg MLVSS at 17°C. These data were obtained by doing time-dependent nitrogen profiles through the denitrification system. Without additional information describing this profiling procedure, it is difficult to assess the accuracy of this experimental technique compared to nitrogen measurements taken on the influent and effluent of a denitrification system. Johnson and Schroepher (17), in their denitrification work used activated sludge and synthetic raw wastewater as an organic carbon source. Analysis of their data, with an assumed 65 percent volatile solids content, results in a denitrification loading factor of 0.39 mg nitrate nitrogen denitrified per day per mg MLVSS at a temperature of 20°C. Mechalas, et al. (38) in their work, cycled bacteria between an aerobic organic carbon removal phase, and an anaerobic denitrification phase in an attempt to use stored bacterial food supplies for a denitrifying energy source. At 18°C, they determined that 0.0062 mg of nitrate and nitrite nitrogen was being denitrified per day per mg of MLVSS.

These four denitrification loading factors, developed under different process conditions, vary by a factor of 40. However, this limited information does show that separate denitrifying sludge systems with organic carbon supplements are more efficient than activated sludge placed under anaerobic conditions with an energy supply provided by wastewater BOD, and that both of these operational approaches are much more efficient than utilizing stored bacterial food supplies for biological denitrification.

With the limited available information on denitrification, a laboratory study was conducted to determine the rate of denitrification under more controlled conditions. The information presented in Figure 21 demonstrated consistently reproducible results for the laboratory studies and a loading factor almost idential to the pilot plant determined value. To further substantiate this denitrification rate, the pilot plant normally operated at a nitrate nitrogen concentration of 5-7 mg/l, while the laboratory studies had an initial nitrate nitrogen concentration of 45 mg/l, but in both cases, an idential denitrification rate was experienced.

A wide variety of common facultative bacteria are capable of denitrification. Two specific genera are the Pseudomonas, which favor a carbohydrate waste, and Bacillus, which prefer a proteinaceous waste. These organisms which are usually present in substantial proportions in activated sludge provide a readily available seed for a denitrification process.

It is generally accepted that different bacterial species perform biochemical reactions at different rates. The rate of denitrification for a given reactor system will therefore be dependent on the dominant genera of bacteria present. Different genera of bacteria and possibly different pH's may be a partial explanation for the variation in reported denitrification rates in similar reported experimentation.

In the pilot plant denitrification studies, methanol was used for energy supply. Methanol proved to be a very effective and easily controlled energy supply in the denitrification process and the quantity required could be predicted using McCarty's (35) equation for methanol demand.

A major difficulty with denitrification in a wastewater system is the control of methanol feed with varying nitrogen and flow conditions: If too little methanol is fed, much of the influent nitrate will only be converted to nitrite with effectively no denitrification. If excess methanol is added, money is wasted, since methanol will probably be carried through the system resulting in effluent BOD, and potential hydrogen sulfide production from the use of sulfate as a hydrogen acceptor after the nitrate supply has been exhausted. A number of suggestions have been presented on controlling methanol feed. The recommendations have included: 1) oxidation reduction potential along with COD determination (59); 2) automated analytical instrumentation, such as a Technicon Auto-Analyser (47); 3) effluent gas chromatographic measurements to determine if excess methanol is being fed (39); 4) or possibly a specific ion electrode in series with some type of continuous prefiltration to prevent electrode fouling.

Ancillary Studies

A number of different studies were conducted to determine whether suspended solids in the final effluent could be minimized. One study, the results of which are presented in Table 7 , indicated that variation in air flow to the flash aerator had a negligible effect on final effluent suspended solids. It was expected that effluent suspended solids would increase with increased aeration rates due to floc shear. At the highest aeration rate studied, a residual of 2.3 mg/l of dissolved oxygen was present in the final effluent. Mulbarger (24) in his attempt to minimize suspended solids in a denitrified effluent, suggested that attached nitrogen bubbles be removed by passing the denitrifying mixed liquor over a weir and using post sedimentation aeration to meet effluent dissolved oxygen requirements.

Another attempt to minimize effluent suspended solids was concerned with laboratory studies in the use of flocculants added to a simulated flash aerator. These results are presented in Figures 22 and 23. In every experimental case, the flocculants did improve suspended solids removal, but did not further reduce the total phosphorus concentration. Alum addition did improve suspended solids removal and also achieved low total phosphorus values in the pilot plant effluent. A residual phosphorus concentration of 0.25 mg/l was achieved by the addition of 3.0 mg/l of Al(III). Thus the use of an Al(III) polishing dosage to the flash aerator for both improved suspended solids and phosphorus removal is recommended.

For the three week period during which the denitrification loading factor was developed, the MLSS concentration in the third reactor system was low, at approximately 1200 mg/l. A review of the final effleunt suspended solids during this three week period indicates an average of 16 mg/l compared to approximately 30 mg/l under ordinary operational circumstances. Therefore, effluent suspended solids could be improved by simply maintaining a third reactor sludge concentration at the minimum level necessary to sustain denitrification.

The chlorination studies presented in Figure 24 were conducted to demonstrate improved economy of disinfection with a nitrified effluent. An observation of the data presented in Figure 24 reveals that for the pilot plant effluent, 4 mg/l of applied chlorine will result in a free chlorine residual of 1 mg/l. Four mg/l of chlorine applied to the South Bend Wastewater Treatment Plant effluent also resulted in a residual of 1 mg/l; however, since the break point had not been reached, this total residual was present in a combined (chloramines) form, which is much less effective as a disinfectant. Therefore, for a given quantity of applied chlorine, better disinfection can be achieved with a nitrified wastewater effluent than with a non-nitrified conventional secondary plant effluent resulting in a considerable saving in chemical costs.

Economic Evaluation

Cost evaluation of the treatment system was a final objective of this project. Table 11 indicates the estimated costs for the additional treatment units in conjunction with conventional primary and secondary treatment for 1 MGD, 10 MGD, and 100 MGD plants. These data are also plotted in Figure 25. The costs associated solely with the additional treatment are itemized in Table 12. It can be observed from these data that based on these estimates the additional cost for removing nitrogen and phosphorus from normal domestic wastewater by these processes will increase the total cost of wastewater treatment in the range of 2 - 2.5 times that for conventional secondary treatment. For a 10 MGD system, for example, the total cost of

Table 11: Estimated Total Treatment Costs for Organic Carbon, Nitrogen and Phosphorus Removal Using the Three Sludge Pilot Plant System.

Cost Element	1 MGD Cost ($)	1 MGD ¢/1000 gal	10 MGD Cost ($)	10 MGD ¢/1000 gal	100 MGD Cost ($)	100 MGD ¢/1000 gal
A. Capital Costs						
1) Preliminary & Primary Treatment						
Sedimentation Tanks (800 gpd/ft^2)	40,000.		250,000.		1,700,000.	
Sludge Collection & Scum Disposal	30,000.		200,000.		1,300,000.	
Preliminary Equipment	15,000.		80,000.		200,000.	
Sub-Total	85,000.	1.8	530,000.	1.1	3,200,000.	0.7
2) High Rate Activated Sludge						
Aeration Tanks	150,000.		900,000.		6,300,000	
Aeration Equipment	75,000.		600,000.		5,100,000.	
Sedimentation Tanks (1000 gpd/ft^2)	30,000.		200,000.		1,300,000.	
Sludge Pumps & Collection Equipmt.	15,000.		100,000.		600,000.	
Chemical Feeders	5,000.		15,000.		40,000.	
Sub-Total	275,000.	5.9	1,815,000.	3.9	13,340,000.	2.9
3) Nitrification						
Aeration Tanks	60,000.		350,000.		2,500,000.	
Aeration Equipment	35,000.		200,000.		1,700,000.	
Sedimentation Tanks (1000 gpd/ft^2)	50,000.		350,000.		2,000,000.	
Sludge Pumps & Collection Equipmt.	15,000.		100,000.		600,000.	
Sub-Total	160,000.	3.4	1,000,000.	2.1	6,800,000.	1.5

Table 11: (Continued)

Cost Element	1 MGD Cost ($)	1 MGD ¢/1000 gal	10 MGD Cost ($)	10 MGD ¢/1000 gal	100 MGD Cost ($)	100 MGD ¢/1000 gal
4) Denitrification						
Denitrification Tanks	55,000.		350,000.		2,400,000.	
Mixing Equipment	15,000.		75,000.		600,000.	
Flash Aerator & Equipment	15,000.		70,000.		250,000.	
Sedimentation Tanks (800 gpd/ft^2)	40,000.		250,000.		1,700,000.	
Sludge Pumps & Collection Equipmt.	15,000.		100,000.		700,000.	
Chemical Feeders	5,000.		15,000.		40,000.	
Sub-Total	145,000.	3.1	860,000.	1.8	5,690,000.	1.2
5) Sludge Handling						
Anaerobic Digestion	100,000.		500,000.		4,000,000.	
Ultimate Discharge	10,000.		200,000.		1,500,000.	
Sub-Total	110,000.	2.4	700,000.	1.5	5,500,000.	1.2
6) Additional Costs						
Administrative & Control Buildings	70,000.		350,000.		1,200,000.	
Chemical Storage Facilities	10,000.		40,000.		100,000.	
Land Purchase	10,000.		50,000.		350,000.	
Sub-Total	90,000.	1.9	440,000.	0.9	1,650,000.	0.4
7) Engineering	60,000.	1.2	300,000.	0.6	2,100,000.	0.5
8) Contingencies	85,000.	1.8	500,000.	1.1	3,500,000.	0.7
Total Capital Costs	$1,010,000.	21.6	$6,145,000.	13.1	$41,730,000.	8.9

Table 11: (Continued)

Cost Element	1 MGD		10 MGD		100 MGD	
	$/year	¢/1000 gal	$/year	¢/1000 gal	$/year	¢/1000 gal
B. Operation & Maintenance Costs						
10) Operational Labor	20,000.		120,000.		800,000.	
11) Maintenance Labor	8,000.		50,000.		250,000.	
12) O & M Supplies	8,000.		50,000.		250,000.	
13) Administrative Overhead	10,000.		60,000.		400,000.	
14) Electric Power & Fuel	3,000.		20,000.		200,000.	
15) Alum	16,000.		140,000.		1,400,000.	
16) Methanol	9,000.		80,000.		750,000.	
Total Operational Maintenance	$74,000.	15.8	$520,000.	11.1	$4,050,000.	8.7

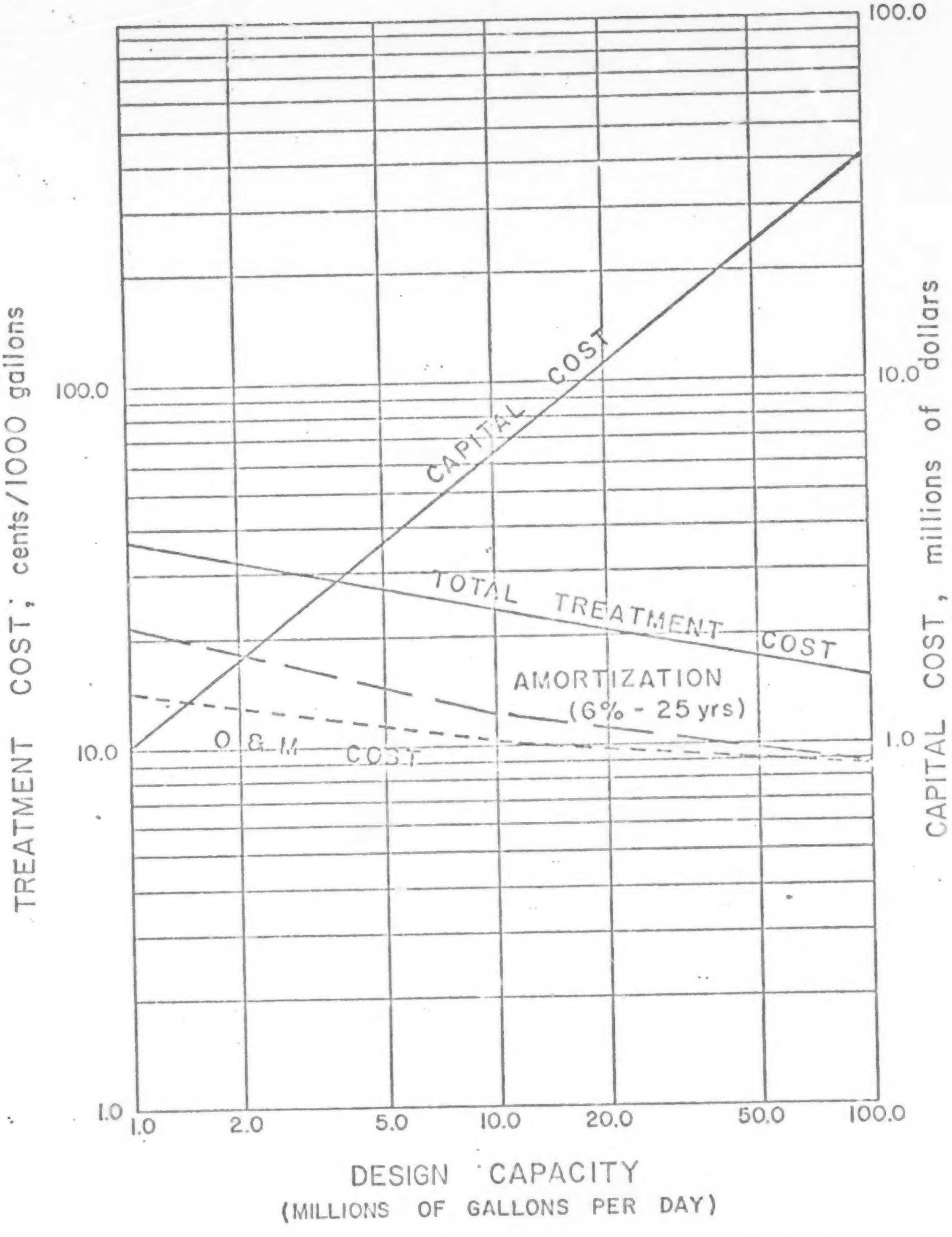


Figure 25: Estimated Treatment Costs for the Pilot System.

Table 12: Summary of Costs for Additional Treatment

Cost Element	1 MGD $/year	1 MGD ¢/1000 gal	10 MGD $/year	10 MGD ¢/1000 gal	100 MGD $/year	100 MGD ¢/1000 gal
A. Capital Costs						
Provision of Chemical Feeders	$ 5,000		$ 15,000		$ 40,000	
Nitrification	160,000		1,000,000		6,800,000	
Denitrification	145,000		860,000		5,690,000	
Sludge Handling	55,000		350,000		2,750,000	
Additional Costs	50,000		240,000		875,000	
Engineering	30,000		150,000		1,050,000	
Contingencies	45,000		250,000		1,750,000	
Total Capital Costs	$490,000	10.5	$2,865,000	6.1	$18,955,000	4.1
B. Operating and Maintenance Cost						
Operational Labor	$ 12,000		72,000		480,000	
Maintenance Labor	4,800		30,000		150,000	
O & M Supplies	5,000		30,000		150,000	
Administrative Overhead	6,000		35,000		250,000	
Electric Power and Fuel	1,800		12,000		120,000	
Alum	16,000		140,000		1,400,000	
Methanol	9,000		80,000		750,000	
Total Operating and Maintenance	$ 54,600	11.6	$399,000	8.5	$3,300,000	7.1

treatment is estimated to be 24.4 ¢/1000 gallons of which 14.6¢ /1000 gallons is attributed to nitrogen and phosphorus removal.

The costs were developed using a number of different sources (60) (61) (62) (63) (64) based on the design parameters deemed most appropriate from the performance of the pilot plant. The major design considerations are summarized in Table 13. The capital costs listed in Table 11 were amortized at 6 percent interest over a 25 year period.

Table 13: Design Criteria Used for Cost Estimate

Primary Treatment - Conventional

Secondary Treatment - Conventional Activated Sludge

5.2 hours hydraulic detention time
clarifier overflow rate - 1000 gpd/ft^2
Alum addition - 11.2 mg/l (as Al)

Nitrification

2.5 hours - hydraulic detention time
clarifier overflow rate - 600 gpd/ft^2

Denitrification

2.5 hours - hydraulic detention time
clarifier overflow rate - 800 gpd/ft^2
methanol addition - 52 mg/l

Sludge Handling

Increased by 50 percent.

SECTION VIII

ACKNOWLEDGMENTS

The project was under the direction of Dr. Mark W. Tenney and Dr. Wayne F. Echelberger, Jr., Associate Professors of Civil Engineering, University of Notre Dame. Although numerous University personnel contributed to the project, special recognition is due for the planning, management, and supervisory efforts of Dr. Kurt J. Guter who selected this project for his Ph. D. thesis, and for the devoted and most competent technical assistance of Mr. Rodney D. Ingraham and Mr. James Berndt.

The support and contributions of the City of South Bend to the project is acknowledged gratefully. The South Bend Wastewater Treatment Plant Commissioners (Mr. Lloyd S. Taylor, Chairman) graciously authorized the use of space, supporting personnel, and equipment for pilot plant construction and operation. Mr. Louis Rague (Superintendent, South Bend Wastewater Treatment Plant) and Mr. Casimir B. Rzepnicki (Assistant Superintendent, South Bend Wastewater Treatment Plant) were instrumental in providing any needed support for the project. The continuing efforts and interest on behalf of these personnel and their employees contributed immeasurably to the orderly development of the project.

The design drawings of the pilot plant were prepared by Greeley and Hansen Engineers, Chicago, Illinois under the direction of Mr. Elmer F. Ballott (partner). The interest in the project and the valuable advice received from Mr. Ballotti and other members of the firm was sincerely appreciated.

The support of the project by the Water Quality Office, Environmental Protection Agency and the sincere interest and assistance provided by the Grant Project Officer, Mr. Edwin F. Barth is gratefully acknowledged.

SECTION IX

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SECTION X

PUBLICATIONS AND PATENTS

No patents were obtained or are pending as a result of this project. A listing of the papers and publications resulting from this project is given below:

1. Echelberger, W. F., Jr., Tenney, M. W., and Ballotti, E. F., "Conceptual Development of a Pilot Plant to Investigate the Removal of Organic and Eutrophying Pollutants from Wastewater," paper presented at the 32nd Annual Conference of the Indiana Water Pollution Control Association, Indianapolis, Indiana (November, 1968).

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SECTION XI

APPENDICES

Appendix A: Construction Drawings of Pilot Plant

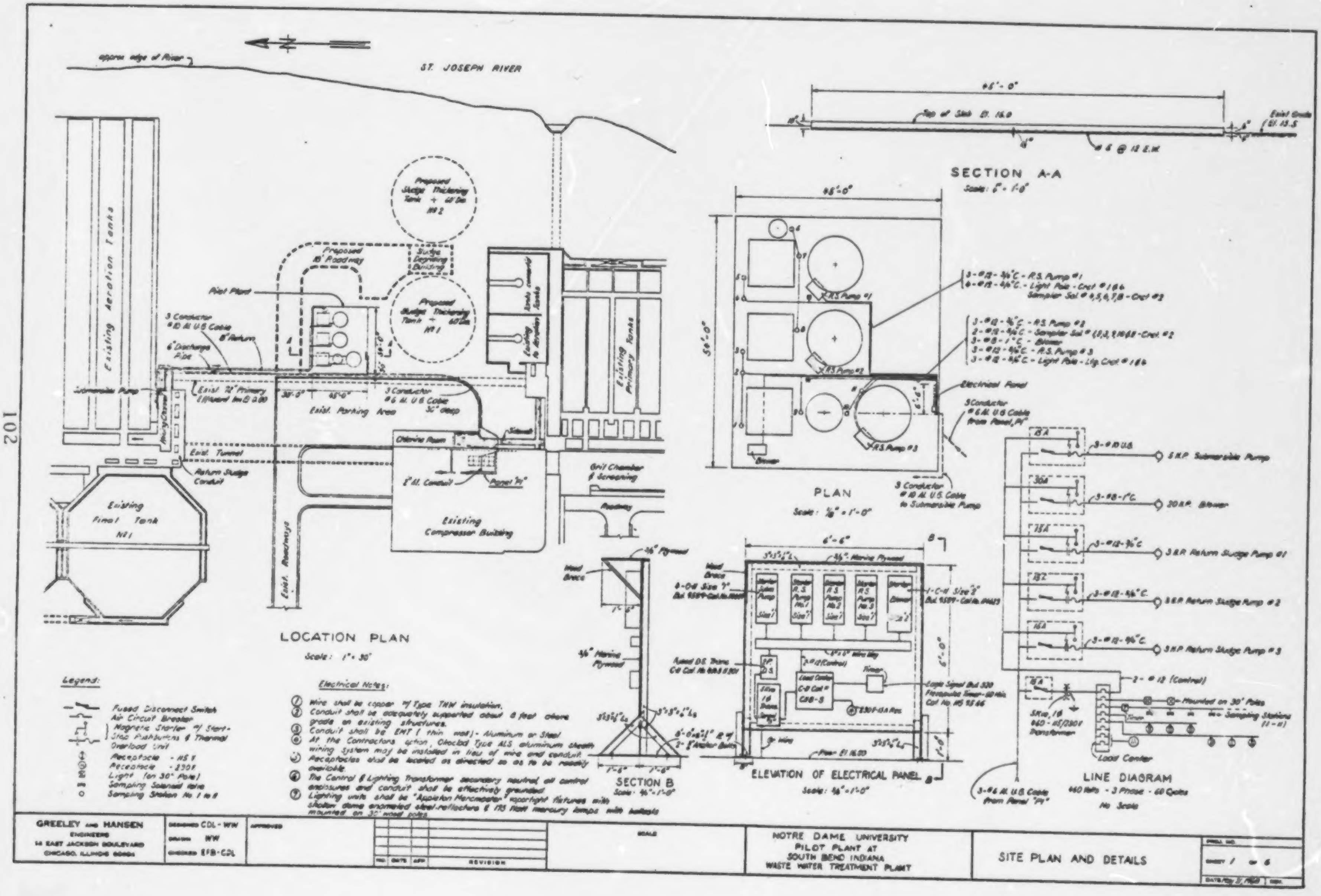
Appendix B: Monthly Summaries of Pilot Plant Operation

Appendix C: Daily Operational Records of Pilot Plant

Appendix D: Monthly Operational Reports - South Bend Wastewater Treatment Plant

APPENDIX A

Construction Drawings of Pilot Plant


N
approx edge of River
ST. JOSEPH RIVER
Existing Aeration Tanks
Proposed Sludge Thickening Tank + 40' Dia. № 2
Proposed Sludge Thickening Tank + 40' Dia. № 1
Sludge Degritting Building
Proposed 16' Roadway
Pilot Plant
3 Conductor #10 Al. U.G. Cable
6" Return
6" Discharge Pipe
Submersible Pump
Exist. 72" Primary Effluent Inv. El 2.80
38'-0"
45'-0"
3 Conductor #6 Al. U.G. Cable 30" deep
Exist. Parking Area
Exist. Tunnel
Return Sludge Conduit
Existing Final Tank №1
Existing Primary Tanks
Chlorine Room
2" Al. Conduit
Panel "P1"
Existing Compressor Building
Grit Chamber & Screening
Roadway
Exist. Roadway
LOCATION PLAN
Scale: 1" = 30'
45'-0"
Top of Slab El. 16.0
Exist. Grade El. 15.5
#6 @ 12 E.W.
SECTION A-A
Scale: 1/2" = 1'-0"
48'-0"
56'-0"
R.S. Pump #1
R.S. Pump #2
R.S. Pump #3
Blower
3-#12-3/4"C - R.S. Pump #1
6-#12-3/4"C - Light Pole - Crct #1 & 6
Sampler Sol. #4,5,6,7,8 - Crct #3
3-#12-3/4"C - R.S. Pump #2
2-#12-3/4"C - Sampler Sol. #1,2,3,9,10 & 11 - Crct #2
3-#8-1"C - Blower
3-#12-3/4"C - R.S. Pump #3
3-#12-3/4"C - Light Pole - Ltg. Crct #1 & 6
Electrical Panel
3 Conductor #6 Al. U.G. Cable from Panel "P1"
3 Conductor #10 Al. U.S. Cable to Submersible Pump
PLAN
Scale: 1/8" = 1'-0"
3/4" Plywood
Wood Brace
3/4" Marine Plywood
1'-6"
SECTION B
Scale: 3/4" = 1'-0"
6'-6"
3/4" Marine Plywood
Wood Brace
Starter Subm. Pump Size 1
Starter R.S. Pump No. 1 Size 1
Starter R.S. Pump No. 2 Size 1
Starter R.S. Pump No. 3 Size 1
Starter Blower Size 2
1-C-H Size 2
Bul. 9589 - Cat. No. 84623
Fused D.S. Trans. C-H Cat. No. 9885 B301
Load Center C-H Cat. No. CSB-S
Timer
230 V - 15A Rec.
Floor El. 16.00
ELEVATION OF ELECTRICAL PANEL
Scale: 3/4" = 1'-0"
15A
30A
3-#10 U.G.
5 H.P. Submersible Pump
3-#8-1"C
20 H.P. Blower
3-#12-3/4"C
3 H.P. Return Sludge Pump #1
3 H.P. Return Sludge Pump #2
3 H.P. Return Sludge Pump #3
2-#12 (Control)
Mounted on 30' Poles
Sampling Stations (1-11)
Transformer
Load Center
3-#6 Al. U.G. Cable from Panel "P1"
LINE DIAGRAM
440 Volts - 3 Phase - 60 Cycles
No Scale
Legend:
Fused Disconnect Switch
Air Circuit Breaker
Magnetic Starter w/ Start-Stop Pushbuttons & Thermal Overload Unit
Receptacle - 115 V
Receptacle - 230 V
Light (on 30' Pole)
Sampling Solenoid Valve
Sampling Station No. 1 to 11

Electrical Notes:

① Wire shall be copper w/ Type THW insulation.
② Conduit shall be adequately supported about 8 feet above grade on existing structures.
③ Conduit shall be EMT (thin wall) - Aluminum or Steel.
④ At the Contractors option, Okoclad Type ALS aluminum sheath wiring system may be installed in lieu of wire and conduit.
⑤ Receptacles shall be located as directed so as to be readily available.
⑥ The Control & Lighting Transformer secondary neutral, all control enclosures and conduit shall be effectively grounded.
⑦ Lighting units shall be "Appleton Mercmaster" floodlight fixtures with shallow dome enameled steel reflectors & 175 Watt mercury lamps with ballasts mounted on 30' wood poles.

GREELEY AND HANSEN
ENGINEERS
14 EAST JACKSON BOULEVARD
CHICAGO, ILLINOIS 60604

DESIGNED CDL - WW
DRAWN WW
CHECKED EFB - CDL

APPROVED

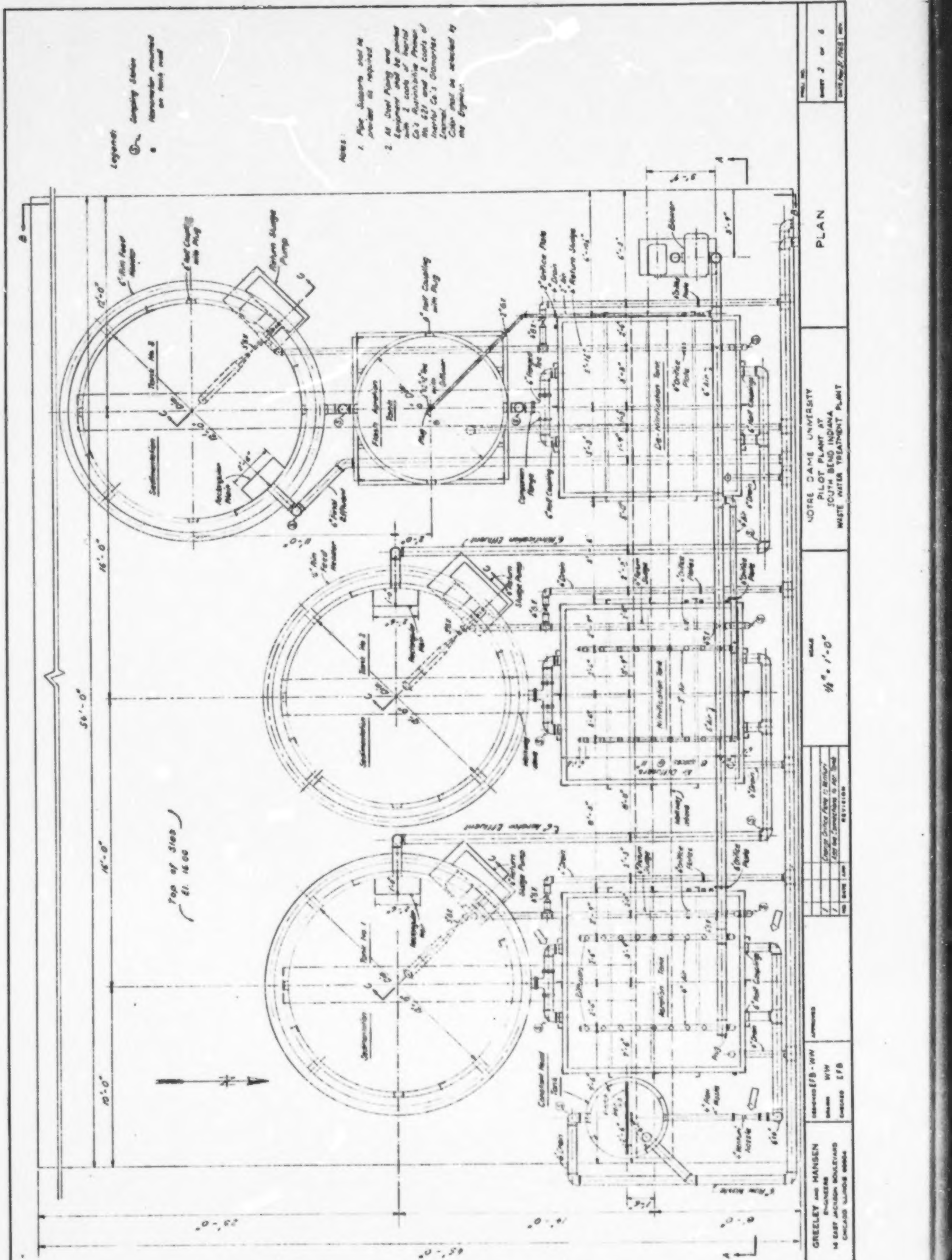
NO.	DATE	APP.	REVISION

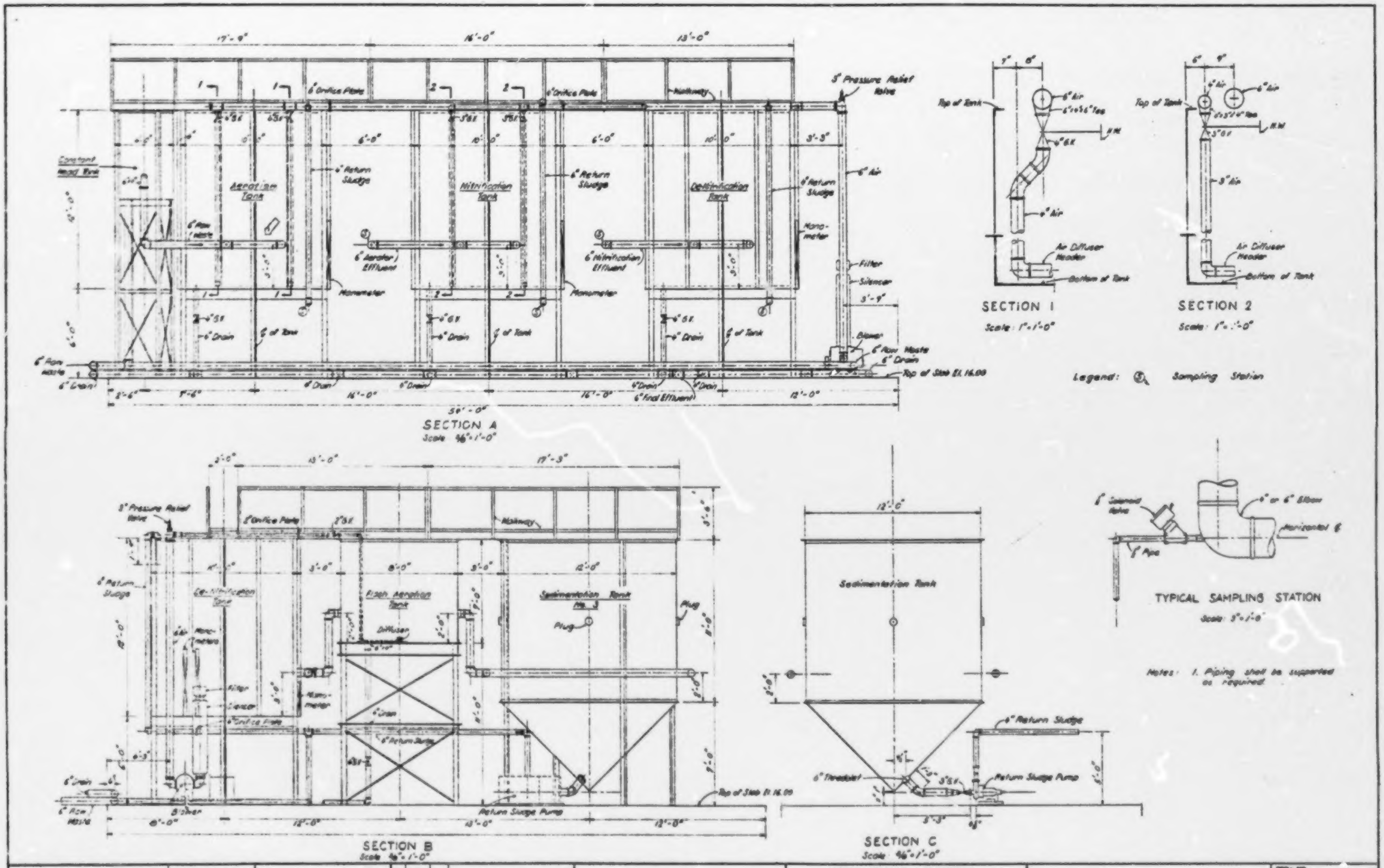
SCALE

NOTRE DAME UNIVERSITY
PILOT PLANT AT
SOUTH BEND INDIANA
WASTE WATER TREATMENT PLANT

SITE PLAN AND DETAILS

PROJ. NO.
SHEET 1 OF 6
DATE May 2, 1969


PLAN
NOTRE DAME UNIVERSITY
PILOT PLANT AT
SOUTH BEND INDIANA
WASTE WATER TREATMENT PLANT
SCALE
1/8" = 1'-0"
GREELEY AND HANSEN
ENGINEERS
14 EAST JACKSON BOULEVARD
CHICAGO ILLINOIS 60604
DESIGNED EFB - WW
DRAWN WW
CHECKED EFB
APPROVED
REVISION
SHEET 2 OF 6
Legend:
Sampling Station
Manometer mounted on tank wall
Notes:
Sedimentation
Tank No. 1
Tank No. 2
Tank No. 3
Aeration Tank
Nitrification Tank
De-Nitrification Tank
Flash Aeration Tank
Constant Head Tank
Return Sludge Pump
Blower
Top of Slab El. 16.00
56'-0"
10'-0"
16'-0"
14'-0"
12'-0"
25'-0"
17'-0"
8'-0"
45'-0"


17'-9"
16'-0"
13'-0"
6" Orifice Plate
Walkway
5" Pressure Relief Valve
Constant Head Tank
Aeration Tank
Nitrification Tank
Denitrification Tank
6" Return Sludge
6" Air
6" Raw Waste
6" Aerator Effluent
6" Nitrification Effluent
Manometer
Filter
Silencer
Blower
6" S.V.
6" Drain
℄ of Tank
6" Raw Waste
6" Drain
Top of Slab El. 16.00
6" Final Effluent
2'-6"
7'-6"
16'-0"
16'-0"
12'-0"
54'-0"
6'-0"
10'-0"
3'-3"
3'-9"
SECTION A
Scale 3/16" = 1'-0"
SECTION 1
Scale: 1" = 1'-0"
SECTION 2
Scale: 1" = 1'-0"
Top of Tank
6" Air
6"x6"x6" Tee
6" S.V.
3" S.V.
3" Air
H.W.
Air Diffuser Header
Bottom of Tank
Legend: Ⓢ Sampling Station
3" Pressure Relief Valve
3" Orifice Plate
6" Return Sludge
De-Nitrification Tank
Flash Aeration Tank
Sedimentation Tank No. 3
Diffuser
Plug
Mano-meter
Filter
Silencer
6" Drain
6" Return Sludge
Blower
6" Raw Waste
Return Sludge Pump
Top of Slab El. 16.00
13'-0"
17'-3"
3'-0"
8'-0"
12'-0"
SECTION B
Scale 3/16" = 1'-0"
Sedimentation Tank
12'-0"
6" Threadolet
3" S.V.
6" Return Sludge
Return Sludge Pump
3'-3"
SECTION C
Scale 3/16" = 1'-0"
1/2" Solenoid Valve
1/2" Pipe
6" or 6" Elbow
Horizontal ℄
TYPICAL SAMPLING STATION
Scale: 3" = 1'-0"
Notes: 1. Piping shall be supported as required.

GREELEY AND HANSEN
ENGINEERS
14 EAST JACKSON BOULEVARD
CHICAGO, ILLINOIS 60604

DESIGNED EFB-WW
DRAWN WW
CHECKED EFB

APPROVED

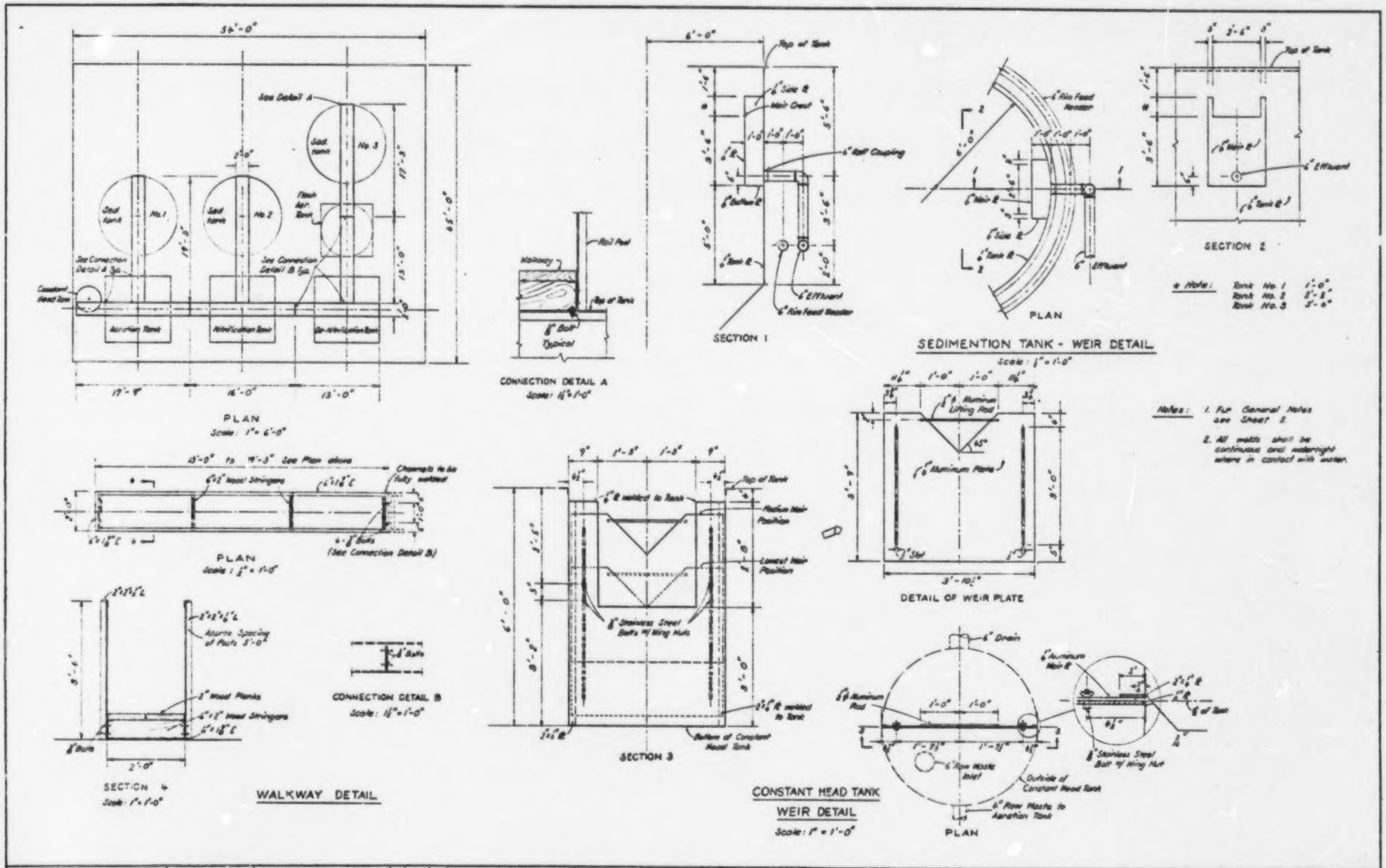
NO.	DATE	APP.	REVISION
1			Add Connection to Air tank

SCALE

NOTRE DAME UNIVERSITY
PILOT PLANT AT
SOUTH BEND INDIANA
WASTE WATER TREATMENT PLANT

SECTIONS AND DETAILS

PROJ. NO.
SHEET 3 OF 6
DATE May 21, 1969 REV.


34'-0"
See Detail A
Sed. tank No. 1
Sed. tank No. 2
Sed. tank No. 3
Flash Aer. Tank
See Connection Detail A Typ.
See Connection Detail B Typ.
Constant Head Tank
Aeration Tank
Nitrification Tank
De-Nitrification Tank
17'-9"
16'-0"
13'-0"
45'-0"
PLAN
Scale: 1" = 6'-0"
Walkway
Rail Post
Top of Tank
5/8" Bolt Typical
CONNECTION DETAIL A
Scale: 1½" = 1'-0"
6'-0"
Top of Tank
6" Side ℄
Weir Crest
6" Roll Coupling
6" Bottom ℄
6" Tank ℄
6" Effluent
6" Raw Feed Header
SECTION 1
6" Raw Feed Header
6" Weir ℄
6" Side ℄
6" Tank ℄
6" Effluent
PLAN
Top of Tank
6" Weir ℄
6" Effluent
6" Tank ℄
SECTION 2
* Note: Tank No. 1 1'-0" Tank No. 2 2'-6" Tank No. 3 3'-6"
SEDIMENTION TANK - WEIR DETAIL
Scale: ½" = 1'-0"
Notes: 1. For General Notes see Sheet 2.
2. All welds shall be continuous and watertight where in contact with water.
13'-0" to 19'-3" See Plan above
2"×6" Wood Stringers
6"×1⅞" ⊏
Channels to be fully welded
4-⅝" Bolts (See Connection Detail B)
PLAN
Scale: ⅜" = 1'-0"
2"×2"×¼" L
Approx. Spacing of Posts 5'-0"
2" Wood Planks
4"×2" Wood Stringers
6"×1⅞" ⊏
⅝" Bolts
2'-0"
3'-6"
SECTION 4
Scale: 1" = 1'-0"
⅝" Bolts
CONNECTION DETAIL B
Scale: 1½" = 1'-0"
WALKWAY DETAIL
9" 1'-3" 1'-3" 9"
Top of Tank
⅝" ℄ welded to Tank
Medium Weir Position
Lowest Weir Position
⅝" Stainless Steel Bolts w/ Wing Nuts
3½" ℄ welded to Tank
Bottom of Constant Head Tank
6'-0"
SECTION 3
1'-0" 1'-0"
⅛" Aluminum Lifting Pad
45°
⅛" Aluminum Plate
⅝" Slot
3'-10½"
DETAIL OF WEIR PLATE
6" Drain
⅛" Aluminum Pad
6" Raw Waste Inlet
Outside of Constant Head Tank
6" Raw Waste to Aeration Tank
PLAN
⅛" Aluminum Weir ℄
⅝" Stainless Steel Bolt w/ Wing Nut
℄ of Tank
CONSTANT HEAD TANK
WEIR DETAIL
Scale: 1" = 1'-0"

GREELEY AND HANSEN
ENGINEERS
14 EAST JACKSON BOULEVARD
CHICAGO, ILLINOIS 60604

DESIGNED BAH-WW
DRAWN WW
CHECKED EFB-BAM

APPROVED

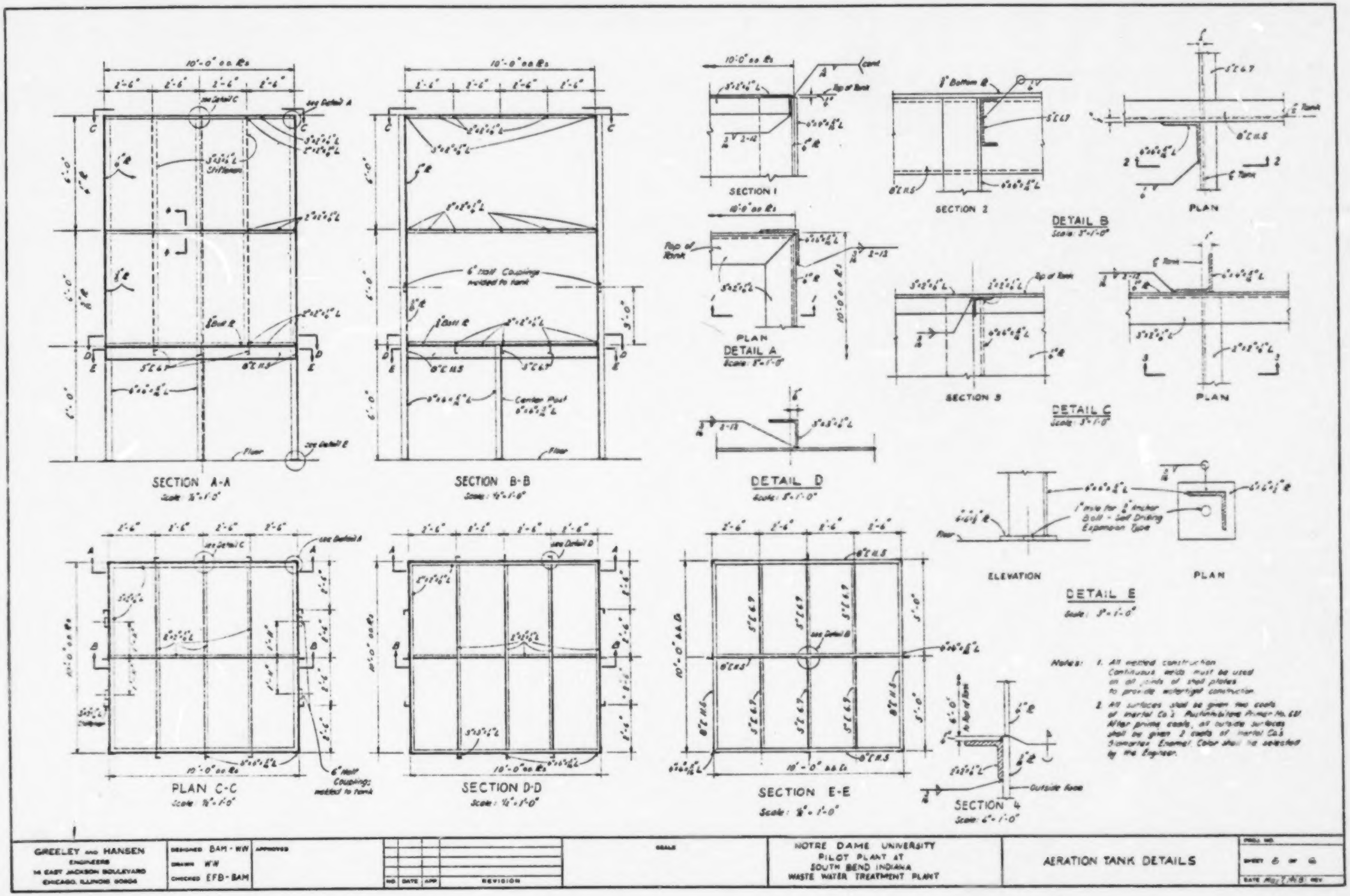
NO.	DATE	APP.	REVISION
1			Lengthen Weir Plate

SCALE

NOTRE DAME UNIVERSITY
PILOT PLANT AT
SOUTH BEND INDIANA
WASTE WATER TREATMENT PLANT

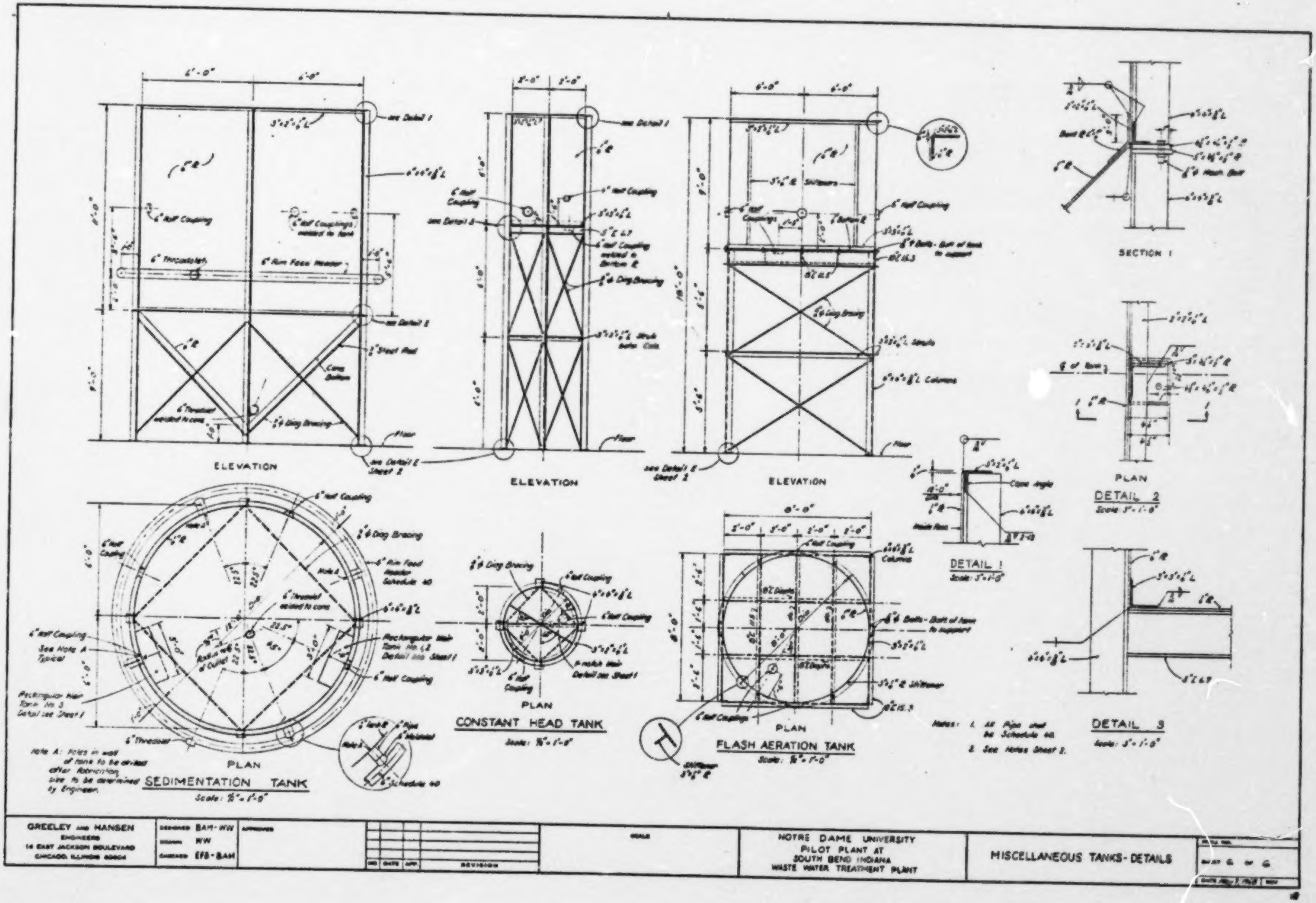
PLAN, WALKWAY AND
MISCELLANEOUS DETAILS

SHEET 4 OF 6
DATE May 7, 1968 REV.


SECTION A-A
Scale: ½" = 1'-0"
SECTION B-B
Scale: ½" = 1'-0"
SECTION 1
SECTION 2
PLAN
DETAIL B
Scale: 3" = 1'-0"
PLAN
DETAIL A
Scale: 3" = 1'-0"
SECTION 3
PLAN
DETAIL C
Scale: 3" = 1'-0"
DETAIL D
Scale: 3" = 1'-0"
ELEVATION
PLAN
DETAIL E
Scale: 3" = 1'-0"
PLAN C-C
Scale: ½" = 1'-0"
SECTION D-D
Scale: ½" = 1'-0"
SECTION E-E
Scale: ½" = 1'-0"
SECTION 4
Scale: 6" = 1'-0"
10'-0" oo R's
2'-6"
6'-0"
3'-0"
see Detail A
see Detail B
see Detail C
see Detail D
see Detail E
Stiffeners
6" Half Couplings welded to tank
Center Post
Floor
Top of Tank
Outside Face
Bottom R
1" Hole for ⅝" Anchor Bolt - Self Drilling Expansion Type
GREELEY and HANSEN
ENGINEERS
14 EAST JACKSON BOULEVARD
CHICAGO, ILLINOIS 60604
DESIGNED BAM - WW
DRAWN WW
CHECKED EFB - BAM
APPROVED
NO DATE APP REVISION
SCALE
NOTRE DAME UNIVERSITY
PILOT PLANT AT
SOUTH BEND INDIANA
WASTE WATER TREATMENT PLANT
AERATION TANK DETAILS
PROJ. NO.
SHEET 6 OF 6
DATE

Notes: 1. All welded construction
Continuous welds must be used
on all joints of shell plates
to provide watertight construction.

2. All surfaces shall be given two coats
of Inertol Co's [illegible] Primer No. 621.
After prime coats, all outside surfaces
shall be given 2 coats of Inertol Co's
Sismarlex Enamel. Color shall be selected
by the Engineer.


ELEVATION
ELEVATION
ELEVATION
PLAN
SEDIMENTATION TANK
Scale: ½" = 1'-0"
PLAN
CONSTANT HEAD TANK
Scale: ½" = 1'-0"
PLAN
FLASH AERATION TANK
Scale: ½" = 1'-0"
SECTION 1
PLAN
DETAIL 2
Scale: 3" = 1'-0"
DETAIL 1
Scale: 3" = 1'-0"
DETAIL 3
Scale: 3" = 1'-0"
6'-0"
6'-0"
see Detail 1
see Detail 2
see Detail 2 Sheet 2
Floor
6" Half Coupling
6" Half Couplings welded to Tank
6" Threadolet
6" Rim Feed Header
Cone Bottom
6" Threadolet welded to cone
Diag Bracing
Note A: Holes in wall of tank to be drilled after fabrication, size to be determined by Engineer.
Rectangular Weir Tank No. 3 Detail see Sheet 1
Rectangular Weir Tank No. 1 & 2 Detail see Sheet 1
6" Half Coupling See Note A Typical
6" Rim Feed Header Schedule 40
6" Schedule 40
V-notch Weir Detail see Sheet 1
Columns
Stiffeners
Stiffener
Bolts - Bolt of tank to support
Cone angle
Inside Face
Mach. Bolt
Notes: 1. All Pipe shall be Schedule 40.
2. See Notes Sheet 2.
GREELEY AND HANSEN
ENGINEERS
14 EAST JACKSON BOULEVARD
CHICAGO, ILLINOIS 60604
DESIGNED BAH-WW
DRAWN WW
CHECKED EFB-BAH
APPROVED
NO. DATE APP. REVISION
SCALE
NOTRE DAME UNIVERSITY
PILOT PLANT AT
SOUTH BEND INDIANA
WASTE WATER TREATMENT PLANT
MISCELLANEOUS TANKS-DETAILS
SHEET 6 OF 6

APPENDIX B

Monthly Summaries of Pilot Plant Operation

Summary of Pilot Plant Operation for May, 1970

Wastewater Parameter	Raw Wastewater	Sludge System I Effluent	Sludge System II Effluent	Sludge System III Effluent	Percent Removal
COD					
Average	340	85	54	55	
Range	180-563	38-107	29-95	36-97	84
Ammonia-N					
Average	6.0	4.3	.3	.3	
Range	1.6-10.2	1.9-7.1	.1-1.2	.0-1.5	96
Nitrite + Nitrate-N					
Average	.8	.8	5.7	.0	(Total
Range	.3-1.4	.3-1.3	3.4-10.0	.0-.0	Inorganic Nitrogen)
Suspended Solids					
Average	159	36	28	22	
Range	74-326	20-57	8-71	10-42	86

Summary of Pilot Plant Operation for June, July 1970

Wastewater Parameter	Raw Wastewater		Sludge System I Effluent		Sludge System II Effluent		Sludge System III Effluent		Percent Removal	
	June	July	June	July	June	July	June	July	June	July
COD										
Average	481	425	80	63	39	48	54	64	89	85
Range	281-935	204-741	40-215	39-115	24-71	27-129	34-71	32-118		
Ammonia-N										
Average	4.4	4.9	4.9	4.2	0.3	0.3	0.3	0.3		
Range	1.8-6.3	3.7-7.9	0.9-8.1	0.6-9.9	0.0-0.8	0.1-0.5	0.0-0.9	0.1-0.7	90 (Total Inorganic Nitrogen)	83
Nitrate + Nitrite-N										
Average	0.3	0.3	0.4	0.7	5.0	4.8	0.2	0.6		
Range	0.1-0.8	0.1-0.8	0.1-1.5	0.0-2.7	2.6-8.1	2.4-12.0	0.0-1.2	0.0-3.5		
Suspended Solids										
Average	283	262	34	25	16	25	39	41	86	84
Range	150-533	148-512	10-87	6-57	4-42	5-80	16-122	15-100		
BOD										
Average	106	127	14	5	5	6	7	10	93	92
Range	54-144	90-180	3-29	1-11	1-7	1-14	3-10	6-13		
Total Phosphorus										
Average	4.3		1.0		1.3		1.2			72
Range	2.5-5.9		0.2-2.1		0.5-3.0		0.7-2.1			

Summary of Pilot Plant Operation for August, September 1970

Wastewater Parameter	Raw Wastewater		Sludge System I Effluent		Sludge System II Effluent		Sludge System III Effluent		Percent Removal	
	August	September	August	September	August	September	August	September	August	September
COD										
Average	433	428	65	63	50	42	62	56	86	87
Range	270-659	294-643	34-91	16-108	34-88	16-70	46-157	29-91		
Ammonia-N										
Average	4.8	5.7	3.8	5.4	0.8	1.6	0.8	1.2	76	60
Range	2.4-10.6	2.9-9.6	1.1-7.9	1.0-12.8	0.2-4.7	0.1-4.6	0.2-5.0	0.1-4.0	(Total Inorganic Nitrogen)	
Nitrate + Nitrate N										
Average	0.2	0.2	0.9	0.6	3.9	4.2	0.4	1.2		
Range	0.0-0.4	0.0-0.7	0.2-3.5	0.0-3.3	1.1-6.5	0.6-11.7	0.0-2.1	0.0-5.2		
Suspended Solids										
Average	277	292	31	27	25	10	30	19	89	93
Range	147-466	190-436	7-63	8-52	5-51	3-43	9-72	6-60		
BOD										
Average	121	124	4	11	3	6	5	12	96	90
Range	89-160	98-141	1-9	7-20	1-5	3-7	3-7	4-22		
Total Phosphorus										
Average	4.7	5.1	1.1	1.4	0.9	0.9	0.8	1.0	83	80
Range	2.7-6.3	2.9-7.6	0.4-2.3	0.3-3.5	0.4-1.6	0.3-1.7	0.4-1.9	0.3-1.8		

Summary of Pilot Plant Operation for October, November 1970

Wastewater Parameter	Raw Wastewater		Sludge System I Effluent		Sludge System II Effluent		Sludge System III Effluent		Percent Removal	
	October	November	October	November	October	November	October	November	October	November
COD										
Average	397		73		54		61			
Range	234-725		46-140		23-116		36-163		85	
Ammonia-N										
Average	9.5	9.0	7.1	6.6	0.4	0.5	0.3	0.3		
Range	4.7-10.4	6.6-11.4	3.0-9.8	2.4-11.6	0.0-2.9	0.0-0.8	0.0-1.8	0.0-0.4	68 (Total Inorganic Nitrogen)	88
Nitrate + Nitrate N										
Average	0.4	0.4	0.4	0.5	7.4	5.9	2.9	0.8		
Range	0.1-1.7	0.2-0.8	0.1-1.0	0.3-0.9	3.7-10.3	3.8-9.4	0.1-11.0	0.1-4.2		
Suspended Solids										
Average	179	193	27	18	17	12	23	34		
Range	74-397	95-391	11-58	11-26	2-58	3-54	7-61	20-50	87	83
Total Phosphorus										
Average	5.5	6.0	1.9	1.0	1.8	0.9	2.0	1.3		
Range	3.1-8.3	2.9-11.0	0.9-2.9	0.4-2.0	0.7-4.5	0.4-2.0	1.1-3.9	0.8-2.4	64	78

APPENDIX C

Daily Operational Records of Pilot Plant

April-May Daily Operational Record
University of Notre Dame Advanced Wastewater Treatment Pilot Plant

		COD			SS			Aeration Solids						NH_3 - N				$NO_3 + NO_3$ - N				
Date	Flow gpm	Raw mg/l	FE mg/l	%R	Raw mg/l	FE mg/l	%R	RI mg/l	SVI	RII mg/l	SVI	RIII mg/l	SVI	Raw mg/l	SI mg/l	SII mg/l	FE mg/l	Raw mg/l	SI mg/l	SII mg/l	FE mg/l	%Sigma Removal
4-1-70	45	336	91		271	18		2734	40.3	1694	62.2	2840	80.7	5.8	4.0	4.6	5.2	.4	.0	.0	.0	
4-3	45	364	82		278	14		3518	42.7	1856	64.5	2538	100.3	4.6	4.1	4.1	5.0	.5	.3	.2	.0	
4-14	38	201	64		72	30		3002	33.4	2690	37.2	4068	71.5	6.5	4.2	8.3	8.0	.7	.0	.5	.0	
4-15	49	196	102		64	15		2502	48.0	2384	67.5	3878	72.3	5.5	6.3	5.8	10.1	1.0	.1	.2	.0	
4-16	45	482	391		112	22		3162	38.0	2342	51.3	3682	95.2	6.5	7.5	9.8	8.8	.8	.0	.2	.0	
4-17	45	992	652		574	39		3026	49.5	2656	65.2	4236	73.1	8.1	2.6	9.9	8.6	.4	.1	.5	.0	
4-22	49	273	66		80	20		2962	74.4	2930	37.5	3164	91.8	5.5	6.6	5.2	5.5	3.0	.0	.0	.0	
4-23	52	398	56		131	15		3444	41.4	2924	65.0	3602	61.0	4.7	3.1	3.8	3.6	1.2	.0	.2	.0	
4-24	45	310	62		72	18		3902	33.4	3340	72.7	3706	86.5	4.2	1.8	2.6	2.8	1.1	.5	.7	.0	
4-28	56	564	65		304	21		3374	35.6	4212	59.5	3804	81.6	7.0	6.2	3.3	3.7	3.5	.6	3.3	.0	
4-30	52	1000	101		255	22		1414	42.8	4940	54.8	4572	74.5	6.2	4.8	.5	.8	2.1	.5	5.7	.0	
Ave. for April	47	465	157	66%	201	21	90%	3003	43.5	2906	57.9	3644	80.7	5.8	4.6	4.8	5.6	1.3	.3	1.0	.0	21%
5-1-70	49	460	97		140	36		2074	50.0	4660	65.2	4386	100.5	3.8	3.4	.2	.8	1.0	.5	6.2	.0	
5-5	56	288	97		97	19		3060	51.5	3830	43.5	7620	76.3	8.0	6.0	1.2	1.5	.9	.9	5.9	.0	
5-6	52	297	67		127	25		2310	49.5	4570	64.0	5240	75.3	6.0	4.7	.2	.2	1.2	1.0	4.5	.0	
5-7	41	563	51		251	20		1572	50.0	4102	73.2	4926	75.5	10.2	5.8	.2	.4	.8	1.0	6.0	.0	
5-8	44	275	50		80	12		1318	53.2	4948	54.5	4936	81.0	8.1	5.6	1.2	.7	1.4	.7	6.5	.0	
5-12	38	420	86		233	42		882	56.9	4606	65.1	5710	99.8	8.4	7.1	.3	.4	.8	.9	10.0	.0	
5-13	46	556	48		326	14		1216	33.3	4942	56.7	5234	63.5	2.8	2.9	.3	.4	.5	.8	6.2	.0	
5-14	45	180	46		74	19		1166	51.5	4392	72.9	4406	79.2	5.5	1.9	.3	.4	.9	.9	3.4	.0	
5-15	45	207	39		256	14		1450	34.5	4710	72.1	4312	90.2	1.6	2.4	.1	.1	1.1	1.2	4.5	.0	
5-19	34	287	61		118	20		1644	56.3	5106	64.6	5846	74.1	5.7	4.2	.3	.3	.8	.6	7.2	.0	
5-20	40	336	37		121	10		1944	30.8	4742	61.2	4584	87.5	7.5	2.9	.3	.3	.6	.6	5.7	.0	
5-21	45	320	38		125	11		1636	42.4	4950	64.5	4472	94.0	6.3	3.1	.3	.3	.8	.5	4.8	.0	
5-22	45	297	36		155	13		1522	46.0	5490	62.0	6058	70.7	5.5	4.2	.3	.3	.6	.3	4.8	.0	
5-27	49	394	59		137	38		893	67.2	3542	93.5	3974	97.5	5.8	5.4	.1	.1	.7	1.3	5.9	.0	
5-28	45	327	65		176	30		1614	62.0	4400	72.8	3812	100.0	6.2	5.3	.4	.3	.3	1.2	5.3	.0	
Ave. for May	44	340	55	84%	159	22	86%	1620	49.0	4599	65.7	5034	84.3	6.0	4.3	.3	.3	.8	.8	5.7	.0	96%

June Daily Operational Record
University of Notre Dame Advanced Wastewater Treatment Pilot Plant

Date	Flow	COD			SS			Sol. P	Aeration Solids			NH3-N				NO3 & NO2-N				In. N	BOD				BOD
								FE	RI	RII	RIII	Raw	SI	SII	FE	Raw	SI	SII	FE		Raw	SI	SII	FE	
	gpm	mg/1	mg/1	%R	Raw	FE	%R	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	%R	mg/1	mg/1	mg/1	mg/1	%R
6-1-70	46	356	67		282	63		0.52	1948	3908	2324	6.3	7.1	0.2	0.3	0.10	0.70	8.10	0.09						
6-2	47	411	48		531	31		0.39	2086	4612	2808	4.8	4.8	0.3	0.3	0.30	0.65	2.55	0.23						
6-3	45	524	64		218	44		0.29	3172	4783	2942	5.8	5.1	0.3	0.3	0.48	0.75	4.30	0.02						
6-4	49	985	63		280	36		0.13	3486	4994	4810	3.9	3.4	0.3	0.3	0.30	0.55	3.40	0.02						
6-5	45	321	53		195	28		0.16	1772	5542	3702	5.5	0.9	0.8	0.5	0.17	0.12	4.50	0.02						
6-9	38	609	51		269	38		0.04	3528	5218	3520			0.2	0.9	0.32	0.04	5.30	0.22						
6-10	42	516	52		266	25		0.29	3788	5774	3486	3.0	4.4	0.2	0.4	0.10	0.12	6.00	0.02		117	24	4.2	6.1	
6-11	54	741	63		255	21		0.23	3352	8350	3346	1.9	5.0	0.0	0.0	0.10	0.04	4.90	0.02						
6-12	52	459	53		250	18		0.36	3526	5124	3156	1.9	2.9	0.2	0.2	0.10	0.12	6.00	0.02		84	8	5.3	4.4	
6-15	58	520	71		395	54		0.16	3208	5130	3168	3.3	5.5	0.2	0.2	0.79	0.83	3.10	0.75						
6-16	50	366	39		200	16		0.23	5112	8278	3442	1.8	4.1	0.3	0.3	0.22	0.06	4.80	0.05						
6-17	50	547	70		246	51		0.81	3650	7118	3610	4.4	6.0	0.2	0.2	0.12	0.28	5.10	0.18		54	8.5	6.0	9.6	
6-18	50	411	51		238	36		0.63	4510	13776	4800	4.1	5.4	0.2	0.3	0.10	0.15	4.60	0.15						
6-19	51	374	47		303	28		0.55	4190	6528	3700	4.3	2.9	0.2	0.2	0.15	1.48	3.10	0.15		120	3.2	1.3	3.4	
6-22	54	401	52		261	122		0.23	3756	5210	3270	6.1	7.1	0.3	0.3	0.68	0.30	5.60	0.05						
6-23	49	281	52		150	31		0.26	4222	13924	3348	4.7	5.9	0.2	0.2	0.28	0.12	5.40	0.25						
6-24	48	416	34		251	29		0.52	5846	6904	3408	4.5	4.8	0.2	0.2	0.05	0.12	4.30	0.08		117	29.3	3.6	5.8	
6-25	47	440	44		284	30		0.49	4672	8758	3438	5.5	4.9	0.3	0.3	0.16	0.18	4.80	0.10						
6-26	49	480	56		292	36		0.36	3304	7186	5324	4.7	4.3	0.2	0.2	0.16	0.33	4.70	0.08		144	9.6	7.2	8.6	
6-29	56	535	55		533	49		0.23	6222	6434	3412	5.8	8.1	0.2	0.2	0.40	0.57	7.80	1.24						
6-30	49	402	47		236	31		0.36	5522	9232	3518	4.8	5.5	0.3	0.3	0.18	0.36	6.00	0.60						
Ave.	49	481	54	89	283	39	86	0.35				4.3	4.9	0.2	0.2	0.25	0.38	4.97	0.21	89	106	13.7	4.6	6.3	94

July Daily Operation Record
University of Notre Dame Advanced Wastewater Treatment Pilot Plant

Date	Flow	COD			SS			Total Phosphorus			Sol. P	Aeration Solids			NH_3-N				NO_3 & NO_2-N				In. N	BOD				BOD
	gpm	mg/l	mg/l	%R	Raw	FE	%R	Raw	FE	%R	FE mg/l	RI mg/l	RII mg/l	RIII mg/l	Raw mg/l	SI mg/l	SII mg/l	FE mg/l	Raw mg/l	SI mg/l	SII mg/l	FE mg/l	% R	Raw mg/l	SI mg/l	SII mg/l	FE mg/l	% R
7-1	49	741	55		512	33					0.52	5746	12386	3468	4.2	4.2	0.3	0.3	0.12	0.34	5.0	0.02		180	3.6	1.7	6.8	
7-2	48	524	94		275	91					0.33	3622	5046	2408	3.9	0.6	0.3	0.3	0.70	0.34	3.0	0.12						
7-3		287	35		148	6						3882	5144	2441	6.9	4.7	0.5	0.2	0.10	0.085	2.6	3.50						
7-6	38	502	64		253	59					0.55	2850	4806	2384	6.1	8.2	0.1	0.1	0.37	0.32	8.0	3.50						
7-7	45	434	44		223	26					0.55	1782	4404	2192	5.3	5.5	0.2	0.1	0.14	0.29	4.9	2.20						
7-8	49	376	65		230	38					0.68	2950	5376	2304	4.8	3.0	0.3	0.7	0.03	0.14	3.3	0.06		130.5	10.8	14.2	13.0	
7-9	50	390	76		318	46					0.39	3244	5576	2146	3.9	1.7	0.3	0.7	0.05	0.61	2.6	0.02						
7-10	46	246	39		169	19					0.23	3146	4880	2210	5.4	4.2	0.3	0.3	0.15	0.63	4.9	0.01		90	9.0	3.7	6.7	
7-13	44	477	118		236						0.23	4050	6436	2600	5.9	9.9	0.3	0.4	0.47	1.20	10.9	0.05						
7-14	60	342	41		219	35					0.45	3946	6570	2674	5.0	7.7	0.4	0.5	0.43	2.70	12.0	0.40						
7-15	49	455	88		414	58		3.14	1.56		0.26	2770	4454	2180	3.9	2.9	0.3	0.3	0.31	2.10	6.9	0.29		93	3.3	5.9	13.0	
7-16	44	414	41		299	19		3.26	0.65		0.26	3168	5112	2402	3.7	1.4	0.3	0.3	0.14	0.79	3.2	0.02						
7-17	47	361	72		218	32		5.23	0.69		0.36	2832	6058	2868	5.7	0.8	0.3	0.6	0.09	0.83	3.2	0.03		138	1.2		11.8	
7-20	60	204	88		340	100		2.48	2.12		0.29	3444	3910	2430	4.9			0.2	0.79	0.93	2.4	0.46						
7-21	58	544	114		167	47		4.10	1.43		0.65	1768	3608	2750	3.7	4.5	0.3	0.4	0.47	0.77	2.6	1.52						
7-22	58	534	37		230	17		4.50	0.91		0.52	1118	3482	2616	4.3	3.2	0.4	0.3	0.19	0.35	4.6	0.95		131	2.75	1.8	5.8	
7-23	50	514	35		168	15		4.16	0.78		0.46	1290	3020	2510	4.4	2.4	0.3	0.3	0.23	0.62	3.6	0.15						
7-24	52	499	65		295	25		5.34	0.91		0.36	1040	2800	2470	4.8	4.1	0.2	0.2	0.23	0.54	3.3	0.06						
7-27	49	250	32		183	44		4.60	1.30		0.46	1458	3678	2602	7.9	7.6	0.4	0.3	0.39	0.01	4.2	0.01						
7-28	49	418	74		293	49		5.85	1.14		0.46	2090	3580	2470	4.5	4.5	0.4	0.4	0.22	0.27	5.8	0.04						
7-29	50	353	46		197	36		4.77			0.52	924	3392	2414	5.7	4.9	0.4	0.4	0.19	0.51	4.7	0.01						
7-30	50	574	100		336	53		4.70	1.27		0.39	836	3644	2258	4.2	2.9	0.2	0.2	0.06	0.52	4.5	0.03						
7-31	49	340	59		307	44		3.85	1.21		0.36	350	3484	2052	4.2	3.3	0.3	0.4	0.37	0.66	3.8	0.01						
Ave.	49.8	425	64	85	262	41	84	4.31	1.16	73	0.42				4.9	4.2	0.3	0.3	0.27	0.68	4.2	0.59	83	127	5.1	7.5	8.5	93

August Daily Operational Record
University of Notre Dame Advanced Wastewater Treatment Pilot Plant

Date	Flow	COD			SS			Total Phosphorus			Aeration Solids			NH_3-N				$NO_3 + NO_2$-N				In. N	BOD				BOD
		Raw	FE	%R	Raw	FE	%R	Raw	FE	%R	RI	RII	RIII	Raw	SI	SII	FE	Raw	SI	SII	FE		Raw	SI	SII	FE	
	gpm	mg/l	mg/l		mg/l	mg/l		mg/l	mg/l		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	%R	mg/l	mg/l	mg/l	mg/l	%R
8-3	42	596	-		289	-		4.5	1.6		2312	1802	1282	6.2	6.3	1.2	0.2	0.2	0.4	5.8	0.0						
8-4	39	364	66		188	42		4.4	0.8		2542	2464	1970	4.0	4.3	0.3	0.3	0.3	0.6	5.6	0.0						
8-5	37	490	51		255	23		4.6	0.7		2696	2852	2100	4.1	3.5	0.3	0.3	0.3	0.5	3.9	0.0						
8-6	46	456	51		289	26		5.0	0.7		3082	3146	2140	4.1	4.0	0.3	0.4	0.4	0.5	4.4	0.0						
8-7	-	318	46		223	37		4.4	1.0		3068	2170	1670	3.8	4.2	0.3	0.3	0.2	0.5	4.1	0.0		99	1	1	4	
8-10	-	559	106		312	72		3.9	-		-	2878	1672	4.0	6.0	4.7	5.0	0.3	0.3	2.9	0.5						
8-11	53	270	61		147	30		4.4	1.0		4764	3400	1800	4.9	4.9	1.0	1.2	0.2	0.2	4.6	2.1						
8-12	46	380	47		270	23		5.2	0.8		4952	3086	1784	4.6	4.3	0.2	0.3	0.1	0.2	3.9	0.6		160	3	3	6	
8-13	50	327	40		208	21		3.7	0.6		2062	2530	1968	3.9	3.8	0.3	0.4	0.2	0.7	4.3	0.0						
8-14	53	401	51		263	20		5.7	0.6		5092	2414	1908	3.8	3.4	0.3	0.3	0.0	0.5	3.6	0.0		156	4	1	3	
8-17	46	659	49		427	16		6.3	0.4		5282	2222	1762	10.6	7.9	0.2	0.2	0.4	1.4	6.5	0.0						
8-18	48	580	56		466	16		4.1	0.4		7578	2188	1708	4.9	2.9	0.3	0.3	0.2	1.2	4.8	0.2						
8-19	52	550	-		325	-		5.6	1.0		4692	2264	1848	3.8	1.1	1.5	0.9	0.0	8	1.1	0.1						
8-20	52	293	73		365	53		2.7	0.7		1952	2076	1800	2.4	1.6	0.4	0.3	0.3	1.1	2.6	0.8						
8-21	50	418	46		275	9		4.4	0.4		2628	1736	1950	3.4	2.1	0.2	1.7	0.1	1.1	2.6	0.9		114	1	2	4	
8-24	-	376	157		276	51		4.8	1.9		3944	864	2592	7.0	6.6	2.9	2.0	0.4	1.1	3.8	0.6						
8-25	-	461	50		283	17		6.2	0.6		3954	826	2612	4.1	2.6	0.2	0.2	0.1	1.2	4.5	0.6						
8-26	-	450	53		244	16		5.0	0.7		3676	764	2450	4.5	2.1	0.4	0.4	0.2	1.2	3.1	0.0		109	9	5	7	
8-27	-	534	52		306	17		5.4	0.6		2966	760	2408	4.2	1.9	0.3	0.2	0.1	1.2	3.1	0.0						
8-28	47	320	55		220	13		4.4	0.4		2806	528	1828	5.0	1.9	0.3	0.4	0.1	1.6	2.9	0.1		89	3	3	6	
8-31	44	291	62		182	38		4.8	1.1		2796	362	1888	7.1	3.6	1.1	2.5	0.7	3.5	4.8	0.8						
Ave	47	433	62	86	277	30	89	4.7	0.8	83				4.8	3.8	0.8	0.8	0.2	0.9	3.9	0.4	76	121	4	3	5	96

September Daily Operational Record
University of Notre Dame Advanced Wastewater Treatment Pilot

Date	Flow	COD			SS			Total Phosphorus			Aeration Solids			NH_3-N				$NO_3 + NO_2$-N				In. N	BOD				BOD
		Raw	FE	%R	Raw	FE	%R	Raw	FE	%R	RI	RII	RIII	Raw	SI	SII	FE	Raw	SI	SII	FE		Raw	SI	SII	FE	
	gpm	mg/1	mg/1		mg/1	mg/1		mg/1	mg/1		mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	%R	mg/1	mg/1	mg/1	mg/1	%R
9-1	46	434	74		333	14		7.6	0.9		3588	78	1812	5.7	1.2	0.3	0.3	0.2	3.3	4.1	3.4						
9-2	46	464	55		277	21		6.6	1.0		3340	81	1750	4.1	1.0	0.7	0.3	0.1	2.6	2.7	1.1		141	7	3	9	
9-3	42	643	89		393	37		6.8	1.3		2736	46	1584	4.8	4.7	3.2	1.5	0.1	0.9	1.6	0.4						
9-4	42	386	80		292	23		4.8	1.2		3118	164	1514	4.8	5.0	4.5	3.4	0.0	0.1	0.6	0.1						
9-8						12										4.6	3.2		-	1.5	0.0						
9-9	46	465	88		227	44		6.3	1.8		2698	484	1704	2.9	6.7	4.4	4.0	0.1	0.3	2.5	1.1		143	8	7	22	
9-10	46	461	51		221	12		5.4	1.4		2852	370	1744	5.5	6.6	4.2	3.1	0.1	0.0	1.4	0.3						
9-11	46	432	44		248	-		2.9	1.0		-	540	1770	7.5	7.3	3.8	2.4	0.1	0.1	2.8	0.9						
9-14	46	480	62		436	20		6.4	0.8		4290	1160	2048	6.7	7.1	2.9	1.4	0.7	1.1	5.2	0.5						
9-15	46	450	36		391	6		3.4	0.3		2536	920	1388	3.8	3.0	0.8	0.7	-	1.1	3.6	1.8						
9-16	48	294	32		193	6		3.8	0.3		2486	1022	1410	4.0	3.1	0.2	0.2	0.1	0.2	3.1	0.5		98	7	6	4	
9-17	46	360	33		210	6		3.0	1.1		2914	1202	1530	5.5	6.0	1.0	0.5	0.1	0.1	4.9	0.3						
9-18	-	538	51		344	8		5.0	1.1		2672	1236	1538	5.2	6.0	0.4	0.2	0.1	0.0	5.2	0.2						
9-21	42	452	91		306	29		6.1	1.0		4510	2090	1964	7.1	2.1	0.2	0.6	0.2	0.1	11.7	0.2						
9-22	48	366	90		190	60		3.1	1.2		2862	2342	1582	7.3	5.5	0.1	0.1	0.1	0.1	3.7	0.2						
9-23	48	342	55		226	15		4.1	1.0		2766	1444	1156	5.2	6.9	0.6	0.4	0.1	0.1	4.6	3.1						
9-24	50	344	32		297	12		3.4	1.0		2076	2410	848	3.5	5.4	0.2	0.2	0.2	0.0	5.8	2.2		114	20	6	14	
9-25	50	325	37		261	18		4.5	0.8		2388	2522	826	6.7	5.1	0.1	0.1	0.2	0.1	5.4	0.6						
9-28	50	410	29		355	17		7.3	1.8		3072	3020	1214	9.6	12.8	0.5	0.2	0.4	0.9	11.6	5.2						
9-29	48	488	33		342	22		7.1	0.8		2172	2132	1110	8.6	7.4	0.2	0.2	0.4	0.7	7.5	4.7						
Ave	47	428	56	87	292	19	93	5.1	1.0	80				5.7	5.4	1.6	1.2	0.2	0.6	4.5	1.2	60	124	11	6	12	90

October Daily Operational Record
University of Notre Dame Advanced Wastewater Treatment Pilot Plant

		COD			SS			Total Phosphorus			Aeration Solids			NH_3-N				$NO_3 + NO_2$ - N				
	Flow	Raw	FE	%R	Raw	FE	%R	Raw	FE	%R	RI	RII	RIII	Raw	SI	SII	FE	Raw	SI	SII	FE	In. N
Date	gpm	mg/l	mg/l		mg/l	mg/l		mg/l	mg/l		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	%R
10-1	46	241	37		142	15		4.6	1.2		2544	2340	1000	7.6	8.4	0.2	0.2	0.4	0.5	7.1	1.6	
10-5	48				121	28					1778	2498	1520	10.3	7.5	0.5	0.4	0.9	1.0	8.8	5.7	
10-6	46				114	15					2302	2762	1020	7.9	9.3	0.5	0.2	0.1	0.2	9.0	7.2	
10-7	50				187	18					3076	3128	1046	6.5	8.4	0.4	0.3	0.1	0.1	8.2	6.4	
10-8	50				198	7					1954	2452	914		9.8	0.4	0.5	1.2	0.2	6.8	0.8	
10-9	50				157	22					2212	2472	660	8.0				0.1	0.1	9.5	11.0	
10-12	48	725	91		106	25		7.3	2.3		2142	2106	1002	5.2	6.0	0.0	0.0	0.8	0.4	8.4	7.2	
10-13	50	362	36		74	12		6.4	1.7		2234	2050	1046	8.1	7.5	0.3	0.3	1.7	0.2	7.5	4.9	
10-14	53	444	38		335	12		5.0	1.6		1562	1590	1028	5.9	4.7	0.1	0.1	0.1	0.1	5.5	1.3	
10-15	50	234	58		218	8		3.1	1.1		3270	2580	1120	4.7	3.0	0.0	0.0	0.6	0.9	3.7	0.1	
10-16	50				147	11					2224	1870	1148	7.3	5.4	0.0	0.0	0.3	0.6	6.3	0.1	
10-19	52	292	38		194	17		5.9	2.1		1030	2448	1706	8.1	9.5	0.5	0.5	0.2	0.4	10.3	3.5	
10-20	52	426	36		225	17		7.5	1.8		948	2382	1618	7.8	8.6	0.5	0.2	0.3	0.6	9.1	3.3	
10-21	48	340	52		180	18		5.1	2.6		1026	2358	2042	7.8	7.2	0.4	0.4	0.2	0.5	7.1	0.9	
10-22	50	238	32		146	15		4.9	1.4		1784	2364	1922	8.0	6.8	0.3	0.4	0.3	0.4	6.9	0.4	
10-23	52				233	16					2720	2334	2056	7.6	6.2	0.3	0.2	0.1	0.3	6.2	0.4	
10-27	47	645	163		104	54		8.3	3.9		2918	2208	2116	10.4	8.0	2.9	1.8	0.2	0.2	8.0	0.7	
10-28	48	447	66		325	56		6.2	2.5		3074	2182	2358	9.0	7.4	0.3	0.3	0.1	0.1	6.2	0.1	
10-29	40	316	85		281	61		3.6	2.1		3498	2190	2338	5.6	5.4	0.2	0.2	0.4				
10-30	42				93	32		3.8	1.3		2488	1910	2546	8.0	6.0	0.3	0.2	0.5	0.6	5.5	0.1	
Ave	49	397	61	85	179	23	87	5.5	2.0	64				7.6	7.1	0.4	0.3	0.4	0.4	7.4	2.9	68

November Daily Operational Record
University of Notre Dame Advanced Wastewater Treatment Pilot Plant

		COD			SS			Total Phosphorus			Aeration Solids			NH_3 - N				NO_3 + NO_2 - N				
	Flow	Raw	FE	%R	Raw	FE	%R	Raw	FE	%R	RI	RII	RIII	Raw	SI	SII	FE	Raw	SI	SII	FE	In. N
Date	gpm	mg/1	mg/1		mg/1	mg/1		mg/1	mg/1		mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	%R
11-2	46				140	37		6.4	2.4		1816	1988	2484	10.4	11.4	0.8	0.4	0.4	0.5	8.1	0.4	
11-3	50				95	34		2.9	2.3		1792	1726	2432	6.6	4.2	0.3	0.3	0.4	0.7	4.8	0.1	
11-4	46				167	47		3.9	1.5		2020	1636	1658	8.8	2.4	0.0	0.0	0.8	0.9	3.8	0.1	
11-5	46				123	50		4.4	1.3		1840	1630	1450	7.8	3.4	0.0	0.0	0.3	0.6	4.0	0.1	
11-6	46				330	32		6.8	1.5		3914	1952	1288	9.0	6.0	0.0	0.0	0.4	0.2	5.1	0.1	
11-9	46				181	37		7.9	1.4		1830	1976	1628	9.2	11.6	0.6	0.4	0.4	0.4	9.4	4.2	
11-10	46				134	20		4.6	1.1		1936	1240	1482	7.6	6.0	0.2	0.2	0.3	0.6	6.8	2.5	
11-11	44				276	27		6.1	0.9		1948	1888	1598	7.8	4.4	0.0	0.0	0.5	0.6	4.2	0.3	
11-12	42				119	22		4.6	0.9		2206	1678	1826	8.4	5.4	0.4	0.3	0.3	0.6	5.1	0.2	
11-13	46				96	26		7.1	1.1		2232	1890	1854	9.2	5.4	0.5	0.3	0.2	0.5	4.6	0.3	
11-16	46				172	37		6.1	0.9		2032	2456	2326	11.0	10.0	0.4	0.3	0.4	0.5	8.1	0.6	
11-19	44				391	47		11.0	1.0		3468	2192	2274	11.4	9.0	0.6	0.4	0.4	0.6	7.2	0.9	
11-20	44				284	26		6.4	0.8		3326	2044	2462	10.0	6.4	0.3	0.3	0.3	0.3	4.8	1.1	
Ave	46				193	34	83	6.0	1.3	78				9.0	6.6	0.5	0.3	0.4	0.5	5.9	0.8	88

APPENDIX D

Monthly Operational Reports --
South Bend Wastewater Treatment Plant

SEND TO BRANCH OFFICE
INDIANA STATE BOARD OF HEALTH

MONTHLY REPORT OF OPERATION
SEWAGE TREATMENT PLANT
ACTIVATED SLUDGE TYPE

REPORT FOR South Bend (CITY)
FOR MONTH OF April 1970
SIGNED BY Casimir B. Rzeznicki

DAY OF MONTH	1 DAY OF WEEK	2 PRECIPITATION—INCHES	3 RAW SEWAGE—M.G.D.	4 PRIMARY TREAT. ONLY—M.G.D.	5 COMPLETE TREATMENT—M.G.D.	6 STREAM FLOW—M.G.D.	7 5-DAY B.O.D.—P.P.M. UPSTREAM OF S.T.P.	8 5-DAY B.O.D.—P.P.M. DOWNSTREAM OF S.T.P.	9 GRIT REMOVED FROM GRIT CHAMBER—CU. FT.	CHEMICALS USED 10 LBS/DAY	11 LBS/DAY	12 LBS/DAY	RAW SEWAGE 13 PH	14 5-DAY B.O.D.—P.P.M.	15 SUSP. SOLIDS—P.P.M.	PRIMARY EFFLUENT 16 PH	17 5-DAY B.O.D.—P.P.M.	18 SUSP. SOLIDS—P.P.M.	FINAL EFFLUENT 19 PH	20 5-DAY B.O.D.—P.P.M.	21 SUSP. SOLIDS—P.P.M.	22 DISSOLVED OXYGEN—P.P.M.	23 RESIDUAL CHLORINE—P.P.M.
1	[illegible]	[illegible]	[illegible]	1.8	38.7	—	—	—	105				7.9	156	161	7.8	108	83	7.8	8.1	3.5	3.9	
2	[illegible]	[illegible]	50.2	8.0	42.2	—	—	—	68				7.5	120	323	7.4	88	169	7.7	7.5	14.5	6.2	—
3	[illegible]	—	47.5	6.0	41.5	—	—	—	105				8.1	84	232	7.7	71	134	7.8	8.6	18.5	6.6	—
4	[illegible]		48.7	5.4	43.3	—	—	—	105				7.8	61	94	7.4	48	86	7.9	8.8	11.5	7.2	—
5	[illegible]	.7	37.2		37.2	—	—	—					7.8	61	69	7.7	50	63	8.0	9.5	16	7.2	—
6	[illegible]	[illegible]	[illegible]	4.3	40.5	—	57	53	135	126	124	99	8.0	99	92	7.7	82	69	7.9	8.0	11.5	6.9	—
7	[illegible]		[illegible]	3.4	41.1	—	—	—	68	—	—	—	8.0	110	111	7.6	109	78	7.8	9.8	12.5	3.3	—
8	[illegible]	[illegible]	43.4	2.3	41.1	—	—	—	68	—	—	—	7.8	131	112	7.7	93	75	8.0	8.0	14.5	3.1	—
9	[illegible]		42.7	1.7	41.0	—	—	—	68	—	—	—	7.4	133	217	7.6	100	78	7.6	8.2	21	2.9	—
10	[illegible]		[illegible]	1.3	41.1	—	—	—	105	—	—	—	7.5	150	115	7.6	90	60	7.7	7.1	8.5	3.6	—
11	5	.7	40.7	1.0	39.7	—	—	—	135	—	—	—	7.8	81	116	7.8	57	72	7.9	10.1	21	4.8	—
12	[illegible]	.7	38.1	0.3	37.8	—	—	—		—	—	—	7.7	58	53	7.7	44	44	8.0	6.9	11.5	6.3	—
13	[illegible]	[illegible]	44.4	4.0	40.4	—	—	—	270	—	—	—	7.5	124	228	7.4	105	138	7.7	9.2	15	6.4	—
14	[illegible]	T	44.5	3.3	41.2	—	—	—	340	—	—	—	7.7	125	84	7.6	108	74	7.8	9.4	12.5	3.9	—
15	[illegible]		44.0	3.3	40.7	—	—	—	135	—	—	—	7.6	132	97	7.5	102	68	7.7	9.5	16.5	4.7	—
16	[illegible]	.11	44.9	3.0	41.9	—	—	—	135	—	—	—	7.5	128	93	7.6	99	54	7.8	8.5	16	4.0	—
17	[illegible]	—	[illegible]	1.4	[illegible]	—	—	—	135	—	—	—	7.5	117	80	7.5	83	67	7.7	8.1	11	4.2	—
18	[illegible]		[illegible]	0.7	[illegible]	—	—	—	135	—	—	—	7.2	62	132	7.1	59	116	7.7	8.3	12.5	5.0	—
19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	—	—	135	—	—	—	7.4	67	79	7.3	57	65	7.7	7.1	12.5	[illegible]	—
20	[illegible]	[illegible]	[illegible]	[illegible]	42.7	—	—	—	135	—	—	—	7.7	124	202	7.7	94	113	7.8	12.7	20.5	5.8	—
21	[illegible]	—	42.0	5.5	42.5	—	—	—	135	—	—	—	7.9	92	97	7.7	77	72	7.9	11.5	21.5	5.5	—
22	[illegible]	—	45.3	3.2	42.1	—	—	—	68	—	—	—	6.8	135	111	7.6	97	71	7.4	7.4	16	3.6	—
23	[illegible]	[illegible]	42.6	5.0	42.1	—	—	—	68	—	—	—	7.8	140	161	7.7	95	41	8.0	10.3	16.5	3.4	—
24	[illegible]	[illegible]	45.5	3.0	42.5	—	—	—	68	—	—	—	7.7	161	123	7.7	101	74	7.5	10.6	15.5	1.1	—
25	[illegible]		43.7	1.5	42.2	—	—	—	135	—	—	—	7.7	66	70	7.5	56	53	8.1	8.0	14	3.8	—
26	[illegible]		40.4	1.0	39.4	—	—	—		—	—	—	7.8	46	54	7.7	48	60	8.1	9.5	20.5	5.5	—
27	[illegible]	.7	41.0	4.6	36.4	—	—	—	68	—	—	—	7.8	130	105	7.7	44	79	8.2	11.6	22	5.8	—
28	[illegible]	[illegible]	44.3	2.5	41.8	—	—	—	105	—	—	—	7.9	124	114	7.6	93	72	8.0	9.4	15	3.1	—
29	[illegible]	.7	44.3	3.2	40.8	—	—	—	68	—	—	—	7.7	138	121	7.7	92	73	8.1	12.7	20	3.4	—
30	[illegible]	[illegible]	44.9	2.6	42.3	—	—	—	68	—	—	—	7.7	86	151	7.7	63	76	8.0	14.7	12.5	1.6	—
31						—	—	—		—	—	—											—
TOTAL		[illegible]	[illegible]	[illegible]	[illegible]				3005														
AVERAGE		[illegible]	[illegible]	[illegible]	[illegible]		57	5.5	100	12.1	12.4	99	7.7	109	128	7.6	82.2	92.8	7.9	9.6	15.1	4.6	
TYPE OF SAMPLE ANALYZED*							G	G		G	G	G	WC	WC	WC	WC	WC	WC	WC	WC	WC	G	
NO. OF PORTIONS COLLECTED DAILY							1	1		1	1	1	24	24	24	24	24	24	24	24	24	9	

DAY OF MONTH	AERATION: MIXED LIQUOR 24 SETTLEABLE SOLIDS % IN 30 MINUTES	25 SUSP. SOLIDS—P.P.M.	26 SLUDGE INDEX	27 DISSOLVED OXYGEN—P.P.M.	28 AIR USED IN AERATION MILLION CU. FT.	RETURN SLUDGE 29 VOLUME—M.G.D.	30 SUSP. SOLIDS—P.P.M.	SLUDGE DIGESTION 31 WASTE ACT. SLUDGE—GAL. X 1000	32 RAW SLUDGE TO DIGESTER—GAL. X 1000	33 TOTAL SOLIDS IN RAW SLUDGE—%	34 TOTAL VOL. SOLIDS IN RAW SLUDGE—%	35 TEMPERATURE IN DIGESTER—°F.	36 PH IN DIGESTER	37 GAS PRODUCTION CU. FT. X 1000	38 GAS USED CU. FT. X 1000	39 SUPERNATANT WITHDRAWN—GAL. X 1000	40 SOLIDS IN SUPERNATANT—%	41 SLUDGE WITHDRAWN GAL. X 1000	42 TOTAL SOLIDS IN DIGESTED SLUDGE—%	43 TOTAL VOL. SOLIDS IN DIGESTED SLUDGE—%
1	20	1846	108	6.1	14.3	10.8	13340	278	126	4.7	61	82	7.0	278	278			210	7.8	50
2	19	2570	74	7.1	19.5	10.7	10320	273	123	5.0	62	83	7.1	264	264					
3	17	2534	67	8.0	19.6	10.8	9450	285	108	5.8	61	83	7.2	285	285					
4	17	2236	62	7.8	19.5	10.8	12720	216	120	5.3	57	83	7.2	305	305			204	7.3	50
5				8.6	19.5	10.9		288	123	5.1	59	83	7.1	280	280			186	3.9	48
6	16	2766	58	8.0	19.4	11.0	11400	11	114	5.0	57	83	7.0	182	182					
7	19	3074	62	7.8	19.2	11.0	11200	22	133	4.4	59	84	6.9	187	187			108	4.4	52
8	20	3074	65	4.5	19.3	10.7	11060	216	132	4.8	62	86	6.7	176	176			276	3.0	51
9	21.5	3036	71	4.2	19.5	10.8	11220	144	138	4.7	63	86	6.8	234	234					
10	19.5	2802	70	5.5	19.4	10.9	10790		126	4.2	74	86	6.7	260	260			359	4.8	50
11	19	2528	75	6.8	19.4	10.8	8620	432	136	4.7	62	86	6.8	201	201			30	2.3	56
12				8.0	19.5	10.7		337	144	4.4	61	85	6.7	236	236					
13	17	2480	69	7.3	19.4	10.7	9940		141	5.1	59	85	6.6	265	265			390	3.6	52
14	12	2146	62	5.8	19.3	10.8	10370	432	132	5.7	62	85	6.7	210	210					
15	19	2252	69	6.0	19.4	10.8	10250	378	141	5.4	59	85	6.7	231	231					
16	21	2216	72	4.5	19.6	10.9	11200	168	123	5.4	58	86	6.7	287	287			384	4.1	45
17	20	2702	74	4.7	21.1	11.0	10050	366	132	5.1	62	86	6.8	276	276					
18	20	2544	78	7.0	20.4	10.8	8830	305	135	4.9	55	85	7.0	267	267			180	4.9	48
19				7.0	20.3	10.9		137	132	5.1	64	86		335	335	120	0.72	25	4.6	47
20	18	2548	71	7.4	20.3	10.5	11120	64	124	5.4	59	86	6.8	307	307					
21	18	2688	67	7.7	20.2	10.8	11830	162	141	5.4	67	87	6.9	311	311			258	4.1	53
22	19	2248	69	6.3	20.4	10.9	12490	65	132	4.7	68	88	6.9	265	265	204	0.38			
23	20	3016	66	5.2	20.3	10.9	12250	133	132	4.1	63	89	6.5	300	300			20	5.2	48
24	17	2570	62	3.9	20.4	10.9	11160	211	132	5.1	61	90	6.9	228	228			180	4.9	44
25	20	2880	69	4.8	20.4	10.9	12740	144	117	5.3	63	91	7.1	260	260	129	2.6	75	2.9	45
26				6.3	19.7	10.8		386	129	4.7	64	92	7.1	263	263					
27	16	2559	63	6.3	20.4	9.8	10880		126	4.7	64	92	7.1	308	308			183	4.5	47
28	16	2532	63	4.2	20.5	10.6	10430	342	102	4.7	65	93	7.0	267	267	192	1.04			
29	18	2400	75	3.3	20.8	10.8	9600		108	4.6	64	99	7.2	265	265					
30	20	2450	82	1.9	20.1	10.9	9760	295	120	5.2	65	95	7.2	303	303			189	5.2	49
31																				
TOTAL					596	323.7		5771	3828					7816	7816	645		3375		
AVERAGE	18.6	2664	71	6.1	19.9	10.8	10852	198	128	5.0	62	87	6.9	261	261	21.5	1.03	112	4.3	51
TYPE OF SAMPLE ANALYZED*	G	G	G	G			G			C	C		C				C		C	C
NO. OF PORTIONS COLLECTED DAILY	1	1	1	18			1			24	24		8				12		8	8

*C-COMPOSITE; G-GRAB.

APPEARANCE OF ACTIVATED SLUDGE GOOD IF BULKING, IN WHAT PERIOD NONE

NUMBER OF SLUDGE BEDS CLEANED OR HRS. VACUUM FILTER RUN QUANTITY OF DRY SLUDGE REMOVED

WEATHER CONDITIONS TOTAL PREC. 5.43 INCHES (4.85 FROM NORM) AVERAGE TEMP. OF RAW SEWAGE

OTHER REMARKS

SUMMARY DATA

PERCENT PURIFICATION	B.O.D.	S.S.
PRIMARY TREATMENT	24.6	27.6
SECONDARY TREATMENT	88.3	79.8
OVERALL TREATMENT	91.2	88.2

DETENTION TIME—HOURS	MAX.	MIN.	AVE.
PRIMARY SETTLING TANK	1.72	1.31	1.49
AERATION TANK x	3.21	2.90	3.01
FINAL SETTLING TANK	1.92	1.70	1.79

x MIXED LIQUOR FLOW

SURFACE FLOW RATE GAL./SQ. FT./DAY	MAX.	MIN.	AVE.
PRIMARY SETTLING TANK	1327	992	1190
FINAL SETTLING TANK xx	1429	1242	1345

xx SEC. INFLUENT FLOW

WEIR OVERFLOW RATE GAL./FT. OF WEIR/DAY	MAX.	MIN.	AVE.
PRIMARY SETTLING TANK	11840	[illegible]	[illegible]
FINAL SETTLING TANK	11658	10227	11599

EST. CENS. POP. 132,000

EQUIV. POP. TREATED= 235288
(LBS. B.O.D. RAW SEWAGE ÷0.17)
LBS S.S. RAW SEWAGE ÷ 0.22 = 234855

C. F. AIR/GAL. SEW. TREATED	0.488
C.F. AIR/LB. B.O.D. REMOVED IN SECONDARY TREATMENT	866
LBS. B.O.D. APPLIED TO AERATOR PER 1000 C.F. AERATOR CAP.	32.37

GARB. TO DIGESTER—% TOT. SOLIDS	
GARB. TO DIGESTER—% TOT. VOL. SOL.	
LBS. GARB. T.S./DAY TO DIGESTER	
LBS. GARB. T.V.S./DAY TO DIGESTER	
TOT. LBS. VOL. SOL./DAY TO DIGESTER	33093
C.F. GAS PROD./DAY/LB. V.S. ADDED	7.87

MAN DAYS AT PLANT ____ PAYROLL/MO. $35,635.56
ELECTRICITY PURCHASED ____ K.W.H. $1,331.40
Fuel & Oil GAS PURCHASED ____ C.F. $891.82
CHEMICALS & SUPPLIES $
MAINTENANCE $8,462.25
OTHER OPERATING COSTS $4,025.9
AMORTIZATION COSTS $
PAYMENTS TO DEPRECIATION FUND $
TOTAL $36,728.45
COST/M.G. SEW. TREAT. $ 27.85
COST/CAPITA/MO. $ 0.24
COST/1015 LB. B.O.D. REMOVED $ 36.18
REVENUE RECEIVED $

S.B.H. [illegible]

SEND TO BRANCH OFFICE
INDIANA STATE BOARD OF HEALTH

MONTHLY REPORT OF OPERATION
SEWAGE TREATMENT PLANT
ACTIVATED SLUDGE TYPE

REPORT FOR South Bend - (CITY)
FOR MONTH OF May 1970
SIGNED BY Casimir B [illegible] #2245

DAY OF MONTH	DAY OF WEEK	PRECIPITATION—INCHES	RAW SEWAGE—M.G.D.	PRIMARY TREAT. ONLY—M.G.D.	COMPLETE TREATMENT—M.G.D.	STREAM FLOW—M.G.D.	5-DAY B.O.D.—P.P.M. UPSTREAM OF S.T.P.	5-DAY B.O.D.—P.P.M. DOWNSTREAM OF S.T.P.	GRIT REMOVED FROM GRIT CHAMBER—CU. FT.	CHEMICALS USED [illegible]	CHEMICALS USED [illegible]	CHEMICALS USED [illegible]	RAW SEWAGE pH	RAW SEWAGE 5-DAY B.O.D.—P.P.M.	RAW SEWAGE SUSP. SOLIDS—P.P.M.	PRIMARY EFFLUENT pH	PRIMARY EFFLUENT 5-DAY B.O.D.—P.P.M.	PRIMARY EFFLUENT SUSP. SOLIDS—P.P.M.	FINAL EFFLUENT pH	FINAL EFFLUENT 5-DAY B.O.D.—P.P.M.	FINAL EFFLUENT SUSP. SOLIDS—P.P.M.	DISSOLVED OXYGEN—P.P.M.	RESIDUAL CHLORINE—P.P.M.	MIXED LIQUOR SETTLEABLE SOLIDS % IN 30 MIN.	MIXED LIQUOR SUSP. SOLIDS—P.P.M.	MIXED LIQUOR SLUDGE INDEX	MIXED LIQUOR DISSOLVED OXYGEN—P.P.M.	AIR USED IN AERATION MILLION CU. FT.	RETURN SLUDGE VOLUME—M.G.D.	RETURN SLUDGE SUSP. SOLIDS—P.P.M.	WASTE ACT. SLUDGE—GAL. X 1000	RAW SLUDGE TO DIGESTER—GAL. X 1000	TOTAL SOLIDS IN RAW SLUDGE—%	TOTAL VOL. SOLIDS IN RAW SLUDGE—%	TEMPERATURE IN DIGESTER—°F.	pH IN DIGESTER	GAS PRODUCTION CU. FT. X 1000	GAS USED CU. FT. X 1000	SUPERNATANT WITHDRAWN—GAL. X 1000	SOLIDS IN SUPERNATANT—%	SLUDGE WITHDRAWN GAL. X 1000	TOTAL SOLIDS IN DIGESTED SLUDGE—%	TOTAL VOL. SOLIDS IN DIGESTED SLUDGE—%
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
1	[illegible]	[illegible]	421	38	390	—	—	—	135	—	—	—	72	54	134	72	83	71	73	11.9	14.5	2.8	—	20	2420	83	2.4	212	10.8	10,230	152	126	6.7	70	96	7.1	334	334	129		60	1.5	36
2	[illegible]	T	[illegible]	64	[illegible]	—	—	—	105	—	—	—	79	70	96	80	47	65	81	10.1	22.5	2.3	—	20	—	—	5.0	206	10.9	—	132	114	6.2	67	94	7.1	351	351	—	—	—	—	—
3	[illegible]		318		380	—	—	—		—	—	—	79	26	71	79	62	61	72	9.1	22	4.4	—				6.4	212	10.9		78	132	4.8	6.2	95	7.0	312	312					
4	[illegible]	T	[illegible]	63	[illegible]	—	2.5	2.0	105	23	.18	78	78	59	84	[illegible]	62	59	[illegible]	7.8	12.5	3.3	—	17	2442	27	5.5	203	10.8	8400	234	138	4.4	67	96	6.7	142	142		—	128	5.3	49
5	[illegible]	T	[illegible]	—	401	—	—	—	68	—	—	—	78	110	105	72	93	65	80	7.5	14	3.9	—	—			4.4	211	10.8	—	64	111	4.2	73	96	6.8	233	233	165	0.30	60	2.7	56
6	[illegible]	—	[illegible]	—	[illegible]	—	—	—	105	—	—	—	77	121	84	77	81	62	79	9.3	16.5	2.9	—	19	2552	25	5.0	216	10.8	8160	211	114	4.1	71	95	6.8	158	158	93	1.10	54	3.6	46
7	[illegible]	—	[illegible]	—	[illegible]	—	—	—		—	—	—	75	169	112	78	92	66	[illegible]	7.8	14.5	2.8	—	16.5	2285	22	6.3	308	10.9	8780	138	117	4.4	71	95	6.9	237	237	186	0.45	30	1.1	54
8	[illegible]	—	373	—	373	—	—	—	68	—	—	—	76	117	142	76	96	76	78	2.5	16	4.0	—	19	2384	73	4.7	218	10.9	9730	137	126	4.6	70	96	7.0	227	227	—	—	—	—	—
9	[illegible]	—	377	—	377	—	—	—	68	—	—	—	78	52	36	78	42	50	81	8.7	23	5.1	—	19	3742	51	5.3	20.9	10.8	10080	58	120	4.2	70	96	7.1	231	231	—	—	39	4.8	48
10	[illegible]	T	376	—	376	—	—	—	105	—	—	—	78	56	18	79	36	57	79	2.5	20	5.4	—	—	—	—	6.8	205	10.8	—	142	128	4.0	71	95	7.1	292	292	—	—	258	3.3	46
11	[illegible]		[illegible]	62	357	—	—	—	285	—	—	—	76	116	115	77	80	73	80	8.6	22.5	5.2	—	17	2104	65	5.9	206	10.8	9490	144	123	3.6	70	96	7.1	273	273	—	—	105	5.0	37
12	[illegible]	[illegible]	405	16	389	—	—	—		—	—	—	76	149	312	76	67	77	77	10.1	20	4.2	—	19	2552	74	5.7	209	10.8	9200	247	120	4.3	66	95	7.1	273	273	—	—	—	—	—
13	[illegible]	[illegible]	[illegible]	14	422	—	—	—	135	—	—	—	79	185	466	78	57	80	8.0	7.4	17	4.8	—	17	2372	72	5.7	205	10.8	9520	280	138	6.1	6.1	94	7.2	272	272	84	—	147	5.1	46
14	[illegible]	[illegible]	[illegible]	2.3	433	—	—	—	240	—	—	—	74	95	184	75	66	117	77	8.9	17	5.5	—	15	2024	74	6.9	198	10.9	8550	137	147	6.4	60	94	7.1	303	303	165	1.39	60	6.3	—
15	[illegible]	[illegible]	[illegible]	55	432	—	—	—	105	—	—	—	77	78	124	76	77	50	78	8.7	13.5	4.4	—	15.5	2386	65	6.0	199	10.3	10,880	196	126	6.4	53	94	7.2	294	294	162	0.20			
16	[illegible]	.21	452	3.4	419	—	—	—	135	—	—	—	78	52	78	77	44	66	81	8.4	14.5	6.0	—	16	2574	63	6.5	199	10.6	9770		126	6.1	56	94	7.2	290	290	312	0.40	96	2.5	46
17	[illegible]		417		417	—	—	—	68	—	—	—	78	47	44	78	35	44	81	7.5	17	5.6	—	—	—	—	6.4	201	10.5	—	392	120	5.1	59	94	7.2	282	282	304	0.56	42	5.1	52
18	[illegible]	—	412	—	412	—	3.2	3.3	135	23	78	92	76	104	103	77	82	72	8.1	2.5	23	3.9	—	19	2326	75	5.7	201	10.5	9090		114	4.5	62	95	7.1	318	237	187	0.73	60	3.4	47
19	[illegible]	—	417		417	—	—	—	68	—	—	—	79	88	92	77	75	62	8.0	9.2	17	2.9	—	18	3544	71	3.9	198	10.5	10250	151	114	4.6	63	96	7.1	206	206	57	0.62	13	3.1	53
20	[illegible]	—	428	10	418	—	—	—	68	—	—	—	77	104	127	77	83	64	8.0	7.0	21	3.5	—	16	2278	76	4.4	203	10.6	9130	203	107	5.1	63	96	7.1	223	223	—	—	—	—	—
21	[illegible]	—	431	15	416	—	—	—	68	—	—	—	77	126	129	75	88	72	77	2.1	23	2.8	—	17.5	2378	56	4.4	207	10.6	7890	264	102	4.6	66	96	7.1	224	224	141	0.18	12	2.4	—
22	[illegible]	[illegible]	424	11	413	—	—	—	68	—	—	—	76	112	94	71	93	67	78	2.8	11.5	3.1	—	17	2156	77	4.5	201	10.6	8750	132	138	4.3	6.5	96	7.1	272	272			12	5.9	42
23	[illegible]	[illegible]	[illegible]	23	[illegible]	—	—	—	90	—	—	—	77	37	107	76	64	52	76	7.9	7.5	4.9	—	19	2220	85	6.1	20.2	10.6	11970	99	126	4.6	6.4	96	7.1	273	228	365	0.15	6.3	5.9	42
24	[illegible]	[illegible]	[illegible]	13	[illegible]	—	—	—		—	—	—	78	68	80	76	54	28	77	2.2	11	5.7	—	—	—	—	7.2	201	10.7	—	314	121	4.5	6.5	96	7.1	272	219	—	—	—	—	—
25	[illegible]	[illegible]	[illegible]	2.7	403	—	—	—	359	—	—	—	79	73	173	77	65	71	79	5.6	16.5	5.9	—	17	3136	80	4.4	[illegible]	10.6	7720	66	123	5.8	56	96	7.1	252	228	385	0.26	27	5.3	46
26	[illegible]		318	—	349	—	—	—		—	—	—	77	126	35	77	29	57	80	7.6	14	4.8	—	19	2202	86	6.1	209	10.6	8890	66	132	5.3	61	96	7.2	233	226	300	0.10	78	6.3	46
27	[illegible]	[illegible]	[illegible]	—	484	—	—	—	68	—	—	—	77	104	97	77	69	64	8.0	7.4	13.5	4.7	—	19	2238	55	5.6	209	10.7	7240	264	136	4.5	66	96	7.2	273	273	48				
28	[illegible]		473	—	473	—	—	—	105	—	—	—	77	125	88	76	88	53	79	8.0	6.5	4.6	—	16	1938	82	6.0	268	10.5	7030	157	111	4.0	72	96	7.2	278	228	171	0.30	30	18.0	80
29	[illegible]	.21	397	—	397	—	—	—	68	—	—	—										4.2	—	20	3194	63	5.3	208	10.5	8630	140	105	3.7	67	96	7.1	265	231	273	0.12	158	4.7	42
30	[illegible]		353	—	353	—	—	—	68	—	—	—	78	92	58	79	75	55	81	9.9	17.5	5.7	—	—	—	—	6.4	[illegible]	10.4	—	278	105	4.1	67	96	7.2	234	234			150	1.1	—
31	[illegible]		323		323	—	—	—		—	—	—	77	41	63	78	69	45	81	8.5	15	5.6	—	—	—	—	6.9	20.5	10.4	—	298	126	3.7	69	96	7.1	238	238					
TOTAL		[illegible]	[illegible]	22.3	[illegible]	—			[illegible]																			[illegible]	331		[illegible]	[illegible]					[illegible]	[illegible]	[illegible]		[illegible]		
AVERAGE		[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	65	[illegible]	[illegible]	[illegible]	[illegible]	—	17.7	[illegible]	74	5.5	20.7	10.7	9133	16.9	121	4.8	6.5	95	7.1	264	251	184	0.93	52	4.8	50
TYPE OF SAMPLE ANALYZED*							G	G		G	G	G	WC	WC	WC	WC	WC	WC	WC	WC	WC	G		G	G	G	G			G			C	C		C				C		C	C
NO. OF PORTIONS COLLECTED DAILY							1	1		1	1	1	24	24	24	24	24	24	24	24	24	9		1	1	1	15			1			24	24		8				12		8	8

*C—COMPOSITE: G—GRAB. WC = WEIGHTED COMPOSITE

APPEARANCE OF ACTIVATED SLUDGE Good
IF BULKING, IN WHAT PERIOD None
NUMBER OF SLUDGE BEDS CLEANED OR HRS. VACUUM FILTER RUN
QUANTITY OF DRY SLUDGE REMOVED
WEATHER CONDITIONS TOTAL PRECIPITATION 3.35" (FROM NORM -.27")
AVERAGE TEMP. OF RAW SEWAGE
OTHER REMARKS #3 DIGESTER OUT OF SERVICE. GETTING READY TO CLEAN.

S.B.H. 34-B

SUMMARY DATA

PERCENT PURIFICATION	B.O.D.	S.S.
PRIMARY TREATMENT	28.7	46.2
SECONDARY TREATMENT	88	74.2
OVERALL TREATMENT	91.5	86.2

DETENTION TIME—HOURS	MAX.	MIN.	AVE.
PRIMARY SETTLING TANK	1.76	1.34	1.57
AERATION TANK *	3.26	2.87	3.05
FINAL SETTLING TANK	1.95	1.68	1.86

* MIXED LIQUOR FLOW

SURFACE FLOW RATE GAL. SQ. FT./DAY	MAX.	MIN.	AVE.
PRIMARY SETTLING TANK	1276	971	1073
FINAL SETTLING TANK **	1422	1225	1324

** SEC. EFFLUENT FLOW

WEIR OVERFLOW RATE GAL./FT. OF WEIR/DAY	MAX.	MIN.	AVE.
PRIMARY SETTLING TANK	11537	8787	9717
FINAL SETTLING TANK	11715	10082	[illegible]

EST. CONN. 150,000
EQUIV. POP. TREATED— (LBS. B.O.D. RAW SEWAGE ÷ 0.17) 202,118
LBS. S.S. RAW SEWAGE ÷ 0.22 = 209,770

C. F. AIR/GAL. SEW. TREATED	0.514
C.F. AIR/LB. B.O.D. REMOVED IN SECONDARY TREATMENT	835
LBS. B.O.D. APPLIED TO AERATOR PER 1000 C.F. AERATOR CAP.	32.37

GARB. TO DIGESTER—% TOT. SOLIDS	
GARB. TO DIGESTER—% TOT. VOL. SOL.	
LBS. GARB. T.S./DAY TO DIGESTER	
LBS. GARB. T.V.S./DAY TO DIGESTER	
TOT. LBS. VOL. SOL./DAY TO DIGESTER	31,655
C.F. GAS PROD./DAY/LB. V.S. ADDED	8.35

MAN DAYS AT PLANT ___ PAYROLL/MO. $ 22,935.35
ELECTRICITY PURCHASED ___ K.W.H. $ 1,220.80
GAS PURCHASED (fuel & oil) ___ C.F. $ 2,265.35
CHEMICALS & SUPPLIES $
MAINTENANCE $ 4,722.11
OTHER OPERATING COSTS $ 216.35
AMORTIZATION COSTS $
PAYMENTS TO DEPRECIATION FUND $
TOTAL $ 32,419.96
COST/M.G. SEW. TREAT. $ 25.41
COST/CAPITA/MO. $ 0.216
COST/1000 LB. B.O.D. REMOVED $ 33.69 (724)
REVENUE RECEIVED $

SEND TO BRANCH OFFICE
INDIANA STATE BOARD OF HEALTH

MONTHLY REPORT OF OPERATION
SEWAGE TREATMENT PLANT
ACTIVATED SLUDGE TYPE

REPORT FOR South Bend (CITY)
FOR MONTH OF June 19 70
SIGNED BY Casimir B. [illegible] # 3345

DAY OF MONTH	DAY OF WEEK (1)	PRECIPITATION—INCHES (2)	RAW SEWAGE ~~[illegible]~~—M.G.D. (3)	PRIMARY TREAT. ONLY—M.G.D. (4)	COMPLETE TREATMENT—M.G.D. (5)	STREAM FLOW—M.G.D. (6)	5-DAY B.O.D.—P.P.M. UPSTREAM OF S.T.P. (7)	5-DAY B.O.D.—P.P.M. DOWNSTREAM OF S.T.P. (8)	GRIT REMOVED FROM GRIT CHAMBER—CU. FT. (9)	CHEMICALS USED [illegible] (10)	CHEMICALS USED [illegible] (11)	CHEMICALS USED [illegible] (12)
1	[illegible]	.55	42.3	2.1	39.2	—	40	38	135	86	89	92
2	[illegible]	.65	42.1	1.0	41.1	—			135	—	—	—
3	[illegible]	.85	41.9	1.3	40.6	—	42	53	135	—	—	—
4	[illegible]	.84	[illegible]	[illegible]	[illegible]	—			17			
5	[illegible]	.18	[illegible]	2.4	[illegible]	—	35	35	135	93	90	90
6	[illegible]	—	40.0	—	40.6	—			68	—	—	—
7	[illegible]	—	[illegible]	—	[illegible]	—			68	—	—	—
8	[illegible]	—	[illegible]	2.0	[illegible]	—	37	35	66	95	93	100
9	[illegible]	—	40.4	2.6	41.9	—	30	30	68	82	84	96
10	[illegible]	—	[illegible]	2.7	41.0	—			68			
11	[illegible]	—	[illegible]	2.3	[illegible]	—			68			
12	[illegible]	—	[illegible]	2.0	[illegible]	—	58	55	68	90	93	92
13	[illegible]	.56	[illegible]	[illegible]	[illegible]	—			68			
14	[illegible]	—	[illegible]	2.3	[illegible]	—			135			
15	[illegible]	T	[illegible]	—	34.5	—	34	33	109	79	82	93
16	[illegible]	T	[illegible]	—	[illegible]	—			[illegible]			
17	[illegible]	.25	[illegible]	2.9	[illegible]	—	45	45	68	72	73	[illegible]
18	[illegible]	—	[illegible]	2.2	[illegible]	—	47	45	68	74	73	85
19	[illegible]	—	[illegible]	—	[illegible]	—	50	50	68	79	78	88
20	[illegible]	.23	[illegible]	—	[illegible]	—			68			
21	[illegible]	.25	[illegible]	[illegible]	[illegible]	—			135			
22	[illegible]	—	[illegible]	2.2	[illegible]	—	47	46	135	[illegible]	73	[illegible]
23	[illegible]	—	[illegible]	2.7	40.6	—	41	27	105	[illegible]	[illegible]	[illegible]
24	[illegible]	T	[illegible]	[illegible]	[illegible]	—	3.6		68	63	81	93
25	[illegible]	—	[illegible]	[illegible]	[illegible]	—		53	68	75	22	91
26	[illegible]	.14	[illegible]	[illegible]	[illegible]	—			135			
27	[illegible]	—	[illegible]	[illegible]	[illegible]	—			165			
28	[illegible]	T	[illegible]	[illegible]	31.6	—			135			
29	[illegible]	—	[illegible]	1.2	[illegible]	—	30	32	105	80	83	96
30	[illegible]	T	[illegible]	1.2	[illegible]	—	50	52	105	83	83	94
31												
TOTAL		[illegible]	[illegible]	[illegible]	[illegible]				[illegible]			
AVERAGE			[illegible]	[illegible]	[illegible]		41	44	[illegible]	[illegible]	[illegible]	[illegible]
TYPE OF SAMPLE ANALYZED*							G	G		G	G	G
NO. OF PORTIONS COLLECTED DAILY							1	1		1	1	1

DAY OF MONTH	RAW SEWAGE pH (13)	RAW SEWAGE 5-DAY B.O.D.—P.P.M. (14)	RAW SEWAGE SUSP. SOLIDS—P.P.M. (15)	PRIMARY EFFLUENT pH (16)	PRIMARY EFFLUENT 5-DAY B.O.D.—P.P.M. (17)	PRIMARY EFFLUENT SUSP. SOLIDS—P.P.M. (18)	FINAL EFFLUENT pH (19)	FINAL EFFLUENT 5-DAY B.O.D.—P.P.M. (20)	FINAL EFFLUENT SUSP. SOLIDS—P.P.M. (21)	FINAL EFFLUENT DISSOLVED OXYGEN—P.P.M. (22)	RESIDUAL CHLORINE—P.P.M. (23)
1	76	91	232	72	67	72	78	25	8.0	6.1	—
2	75	124	137	75	96	60	80	97	6.0	5.1	—
3	77	123	73	75	90	48	80	94	2.0	4.2	—
4	77	94	133	78	77	51	78	77	6.0	5.4	—
5	77	82	116	77	57	45	79	56	8	4.8	—
6	76	102	78	76	67	55	75	9.1	9	5.5	—
7	77	44	46	76	39	31	77	9.0	8.5	5.1	—
8	77	72	81	73	28	70	78	7.3	13	4.4	—
9	76	123	305	76	77	112	77	23	13	2.8	—
10	73		116	74		62	79		3.5	3.3	—
11	73	90	118	75	87	65	71	10.5	11	2.3	—
12	76	109	153	76	48	61	77	3.3	10.5	3.5	—
13	76	112	313	78	46	72	80	11.5	6.0	[illegible]	—
14	77	44	46	78	31	40	79	6.8	4.6	5.3	—
15	77	71	63	77	66	59	80	7.1	7.6	4.6	—
16	76	183	74	76	94	37	[illegible]	13.6	12	4.8	—
17	76	90	158	77	63	103	77	7.9	1.6	4.6	—
18	78	121	38	75	68	72	78	9.3	10	4.3	—
19	77	113	99	76	61	68	79	4.5	14	2.5	—
20	81	63	318	77	42	95	83	10.6	12.5	3.2	—
21	71	102	222	76	45	60	78	11	9.5	5.6	—
22	77	115	78	76	56	77	77	12.7	10.5	3.3	—
23	76	107	98	77	42	63	78	10.8	10	2.1	—
24	76	98	95	75	22	[illegible]	78	71	9.0	3.1	—
25	76	93	[illegible]	76	84	61	79	10.2	8.5	5.0	—
26	76	74	153	78	76	23	78	12.6	13	5.2	—
27	[illegible]	61	117	[illegible]	48	[illegible]	[illegible]	7.9	[illegible]	5.6	—
28	77	56	42	77	37	33	79	10.4	37.5	4.5	—
29	76	93	92	76	85	62	77	12.7	12	4.5	—
30	76	150	116	23	87	74	26	[illegible]	18	1.0	—
31											
TOTAL											
AVERAGE	[illegible]	[illegible]	127	[illegible]	[illegible]	[illegible]	78	10.2	11.7	4.9	
TYPE OF SAMPLE ANALYZED*	WC	WC	WC	WC	WC	WC	WC	WC	WC	G	
NO. OF PORTIONS COLLECTED DAILY	24	24	24	24	24	24	24	24	24	9	

DAY OF MONTH	AERATION MIXED LIQUOR SETTLEABLE SOLIDS % IN 30 MINUTES (24)	AERATION MIXED LIQUOR SUSP. SOLIDS—P.P.M. (25)	AERATION MIXED LIQUOR SLUDGE INDEX (26)	AERATION MIXED LIQUOR DISSOLVED OXYGEN—P.P.M. (27)	AIR USED IN AERATION MILLION CU. FT. (28)	RETURN SLUDGE VOLUME—M.G.D. (29)	RETURN SLUDGE SUSP. SOLIDS—P.P.M. (30)
1	16	1926	87	5.3	207	10.4	7990
2	17	2148	79	6.3	205	10.3	8380
3	20	3372	34	5.7	201	10.5	9570
4	17	2238	81	6.2	201	10.5	7880
5	21	2356	89	1.8	202	10.3	9890
6	18	2026	79	6.3	204	10.4	8300
7				6.9	204	10.5	
8	18	1972	91	6.2	215	10.5	7330
9	18	1952	92	4.8	202	10.4	8860
10	21	2094	100	4.6	203	10.3	7380
11	21	2214	95	3.4	204	10.4	7720
12	21	2156	79	4.4	204	10.3	7690
13	18	1914	97	4.7	201	10.3	2650
14				5.9	206	10.4	
15	16	1772	88	6.9	205	10.5	1370
16	17	1544	87	5.2	204	10.5	[illegible]
17	17	1914	81	5.4	204	10.6	6680
18	17	1932	88	3.4	205	10.6	4620
19	20	1956	102	4.3	214	10.7	7290
20	23	1804	120	4.8	215	10.5	6510
21				6.1	193	10.6	
22	17	1716	99	5.2	186	10.3	5000
23	18	1962	92	4.1	205	10.4	7050
24				4.2	203	10.4	
25	16	1982	81	6.1	206	9.3	3880
26	20	2210	98	6.7	205	[illegible]	6020
27				6.8	203	6.9	
28				6.1	207	8.7	
29	14	1874	74	5.8	207	10.4	574
30	16	1990	81	2.4	209	10.5	6340
31							
TOTAL					[illegible]	303	
AVERAGE	[illegible]	2049	87	5.4	205	10.1	7112
TYPE OF SAMPLE ANALYZED*	G	G	G	G			G
NO. OF PORTIONS COLLECTED DAILY	1	1	1	18			1

DAY OF MONTH	WASTE ACT. SLUDGE ~~[illegible]~~—GAL. X1000 (31)	RAW SLUDGE TO DIGESTER—GAL. X1000 (32)	TOTAL SOLIDS IN RAW SLUDGE—% (33)	TOTAL VOL. SOLIDS IN RAW SLUDGE—% (34)	TEMPERATURE IN DIGESTER—°F. (35)	pH IN DIGESTER (36)	GAS PRODUCTION CU. FT. X 1000 (37)	GAS USED CU. FT. X 1000 (38)	SUPERNATANT WITHDRAWN—GAL. X 1000 (39)	SOLIDS IN SUPERNATANT—% (40)	SLUDGE WITHDRAWN GAL. X 1000 (41)	TOTAL SOLIDS IN DIGESTED SLUDGE—% (42)	TOTAL VOL. SOLIDS IN DIGESTED SLUDGE—% (43)
1		127	3.9	71	96	72	330	220	210		30		
2	137	135	5.2	69	96	71	196	196	252		132	5.1	42
3	168	132	5.6	66	96	71	343	243	9		9	2.2	81
4	340	132	4.6	67	96	72	285	282	48	0.31	107	3.3	76
5	266	105	4.2	67	96	72	229	235	142	0.32	16	1.7	
6	180	114	4.0	59	96	72	245	245			45	[illegible]	72
7	384	126	4.3	62	96	72	253	253	72		12	16.6	86
8	96	132	4.1	64	96	72	245	245	149	0.36	214	5.0	46
9	327	126	4.6	67	96	72	191	191			121	52	46
10	185	123	4.2	67	96	72	237	237	121	0.26	25	39	50
11	168	126	4.4	70	96	72	236	236					
12	398	129	4.4	69	96	72	240	240					
13	324	121	4.2	66	96	72	245	245			124	4.9	42
14	441	108	4.7	67	96	72	228	228	216	0.30			
15		111	4.5	63	96	72	236	236					
16	392	[illegible]	4.2	65	96	72	262	262			135	9.3	44
17	172	104	4.0	70	96	72	229	223	124	0.35	27		
18	172	120	4.2	70	96	72	227	227	24	1.30	12	241	72
19	346	156	4.0	67	96	72	231	231	3.3	0.34	127	4.2	43
20	254	156	3.6	66	96	72	269	269	277	0.48			
21	192	144	3.9	61	96	72	249	247					
22	160	135	4.2	65	96	77	269	269	15	0.28	120	5.1	50
23	234	138	3.8	69	96	71	243	243	18	0.36	20	5.3	57
24	116	138	3.9	77	96	71	256	256	21		37	11.5	75
25	120	144	3.8	74	96	72	[illegible]	[illegible]	9	0.10	54	5.4	50
26	120	138	4.2	57	96	72	235	234	225	0.70	123	5.3	52
27	132	150	4.5	54	96	72	[illegible]	[illegible]	9		6	[illegible]	80
28	130	[illegible]	3.9	69	96	72	364	364			136	4.3	99
29	61	123	3.2	70	96	72	346	346	364	0.56	31	7.7	26
30	68	96	3.3	71	96	72	208	208	9		9		
31													
TOTAL	[illegible]	3763					[illegible]	[illegible]	[illegible]		[illegible]		
AVERAGE	206	130	4.2	66	96	72	[illegible]	241	[illegible]	[illegible]	19	[illegible]	[illegible]
TYPE OF SAMPLE ANALYZED*			C	C		C				C		C	C
NO. OF PORTIONS COLLECTED DAILY			24	24		7				12		8	8

*C—COMPOSITE; G—GRAB. WC = WEIGHTED COMPOSITE

APPEARANCE OF ACTIVATED SLUDGE Good

NUMBER OF SLUDGE BEDS CLEANED OR HRS. VACUUM FILTER RUN ______

IF BULKING, IN WHAT PERIOD ______

WEATHER CONDITIONS Total Precipitation 3.92" (+ .34 from Norm)

QUANTITY OF DRY SLUDGE REMOVED ______

OTHER REMARKS # 3 Digester out of Service

AVERAGE TEMP. OF RAW SEWAGE ______

S.B. [illegible]

SUMMARY DATA

PERCENT PURIFICATION	B.O.D.	S.S.
PRIMARY TREATMENT	29.2	47.5
SECONDARY TREATMENT	84.2	72.8
OVERALL TREATMENT	88.8	91

DETENTION TIME—HOURS	MAX.	MIN.	AVE.
PRIMARY SETTLING TANK	1.73	1.41	1.57
AERATION TANK *	4.91	2.97	3.21
FINAL SETTLING TANK	1.96	1.73	1.91

* Mixed Liquor Flow

SURFACE FLOW RATE GAL. SQ. FT. DAY	MAX.	MIN.	AVE.
PRIMARY SETTLING TANK	1268	987	1173
FINAL SETTLING TANK **	1380	1222	1258

** Sec. Influent Flow

WEIR OVERFLOW RATE GAL. FT. OF WEIR DAY	MAX.	MIN.	AVE.
PRIMARY SETTLING TANK	[illegible]	[illegible]	[illegible]
FINAL SETTLING TANK	[illegible]	[illegible]	[illegible]

Est. Conn. 150,000

EQUIV. POP. TREATED— 176,512

LBS. B.O.D. RAW SEWAGE [illegible] = 320,280

C. F. AIR GAL. SEW. TREATED	1.535
C.F. AIR LB. B.O.D. REMOVED IN SECONDARY TREATMENT	1120
LBS. B.O.D. APPLIED TO AERATOR PER 1000 C.F. AERATOR CAP.	27.74

GARB. TO DIGESTER—% TOT. SOLIDS	
GARB. TO DIGESTER—% TOT. VOL. SOL.	
LBS. GARB. T.S./DAY TO DIGESTER	
LBS. GARB. T.V.S./DAY TO DIGESTER	
TOT. LBS. VOL. SOL./DAY TO DIGESTER	30,054
C.F. GAS PROD./DAY/LB. V.S. ADDED	7.12

MAN DAYS AT PLANT ______ PAYROLL/MO. $ 28,894.66
ELECTRICITY PURCHASED ______ K.W.H. $ 1091.60
plant & Ed
GAS PURCHASED ______ C.F. $ 69.71
CHEMICALS & SUPPLIES $ ______
MAINTENANCE $ 7720.55
OTHER OPERATING COSTS $ 213.53
AMORTIZATION COSTS $ ______
PAYMENTS TO DEPRECIATION FUND $ ______
TOTAL $ 38,977.05
COST/M.G. SEW. TREAT. $ 86.70
COST/CAPITA/MO. $ 0.27
COST/1000 LB. B.O.D. REMOVED $ 40.47
REVENUE RECEIVED $ ______

SEND TO BRANCH OFFICE
INDIANA STATE BOARD OF HEALTH

MONTHLY REPORT OF OPERATION
SEWAGE TREATMENT PLANT
ACTIVATED SLUDGE TYPE

REPORT FOR South Bend (CITY)
FOR MONTH OF July 1970
SIGNED BY Casimir B. Pajkowski

SUMMARY DATA

PERCENT PURIFICATION	B.O.D.	S.S.
PRIMARY TREATMENT	[illegible]	397
SECONDARY TREATMENT	795	93.2
OVERALL TREATMENT	861	90.9

DETENTION TIME—HOURS	MAX.	MIN.	AVE.
PRIMARY SETTLING TANK	1.87	1.37	1.58
AERATION TANK *	3.41	2.92	3.09
FINAL SETTLING TANK	2.07	1.71	1.83

* MIXED LIQUOR FLOW

SURFACE FLOW RATE GAL. PER SQ. FT. DAY	MAX.	MIN.	AVE.
PRIMARY SETTLING TANK	1250	914	1073
FINAL SETTLING TANK **	1460	1153	1304

** SEC INFLUENT FLOW

WEIR OVERFLOW RATE GAL. PER LF OF WEIR DAY	MAX.	MIN.	AVE.
PRIMARY SETTLING TANK	11921	7279	8811
FINAL SETTLING TANK	11659	9407	[illegible]

EST. CONN. POP. 150,000
EQUIV. POP. TREATED 210,182

C.F. AIR/GAL. SEW. TREATED	0.566
C.F. AIR/LB. B.O.D. REMOVED IN SECONDARY TREATMENT	2683
LBS. B.O.D. APPLIED TO AERATOR PER 1000 C.F. AERATOR CAP.	10.90

GARB. TO DIGESTER—% TOT. SOLIDS	
GARB. TO DIGESTER—% TOT. VOL. SOL.	
LBS. GARB. T.S./DAY TO DIGESTER	
LBS. GARB. T.V.S./DAY TO DIGESTER	
TOT. LBS. VOL. SOL./DAY TO DIGESTER	36796
C.F. GAS PROD./DAY/LB. V.S. ADDED	7.74

MAN DAYS AT PLANT ___ PAYROLL, MO. $ 28,568
ELECTRICITY PURCHASED ___ K.W.H. $ 12,946
GAS PURCHASED diesel + fuel C.F. $ 1,8015
CHEMICALS & SUPPLIES $ ___
MAINTENANCE $ 2,692.83
OTHER OPERATING COSTS $ 1,823.0
AMORTIZATION COSTS $ ___
PAYMENTS TO DEPRECIATION FUND $ ___
TOTAL $ 42,6[illegible]
COST/M.G. SEW. TREAT. $ 34.65
COST/CAPITA, MO. $ 0.28
COST/1000 LB. B.O.D. REMOVED $ 910 46.86
REVENUE RECEIVED $ ___

C-COMPOSITE; G-GRAB. WC = WEIGHTED COMPOSITE
APPEARANCE OF ACTIVATED SLUDGE GOOD
IF BULKING, IN WHAT PERIOD NONE
NUMBER OF SLUDGE BEDS CLEANED OR HRS. VACUUM FILTER RUN ___
QUANTITY OF DRY SLUDGE REMOVED ___
WEATHER CONDITIONS TOTAL PRECIPITATION 4.14" (FROM NORM + .67")
AVERAGE TEMP. OF RAW SEWAGE ___
OTHER REMARKS #3 DIGESTER - OUT OF SERVICE

S.B.H. 54-26

SEND TO BRANCH OFFICE
INDIANA STATE BOARD OF HEALTH

MONTHLY REPORT OF OPERATION
SEWAGE TREATMENT PLANT
ACTIVATED SLUDGE TYPE

REPORT FOR South Bend. (CITY)
FOR MONTH OF August 1970
SIGNED BY Casimir B. Dzyn[illegible] #2245

SUMMARY DATA

PERCENT PURIFICATION	B.O.D.	S.S.
PRIMARY TREATMENT	32.3	40.3
SECONDARY TREATMENT	83.0	78.0
OVERALL TREATMENT	88.7	86.8

DETENTION TIME - HOURS	MAX.	MIN.	AVE.
PRIMARY SETTLING TANK	1.95	1.47	1.63
AERATION TANK ✱	3.53	2.95	3.15
FINAL SETTLING TANK	2.16	1.72	1.87

✱ MIXED LIQUOR FLOW

SURFACE FLOW RATE GAL. SQ. FT. DAY	MAX.	MIN.	AVE.
PRIMARY SETTLING TANK	1166	875	1050
FINAL SETTLING TANK ✱✱	1386	1104	1278

✱✱ SEC. INFLUENT FLOW

WEIR OVERFLOW RATE GAL. FT. OF WEIR DAY	MAX.	MIN.	AVE.
PRIMARY SETTLING TANK	10,516	7925	9459
FINAL SETTLING TANK	11,418	9091	10525

EST. CONN. 150,000
EQUIV. POP. TREATED 240353
LBS. S.S. RAW [illegible] 0.2 = 161795

C. F. AIR/GAL. SEW. TREATED	0.512
C.F. AIR/LB. B.O.D. REMOVED IN SECONDARY TREATMENT	888
LBS. B.O.D. APPLIED TO AERATOR PER 1000 C.F. AERATOR CAP.	31.16

CARB. TO DIGESTER—% TOT. SOLIDS	
CARB. TO DIGESTER—% TOT. VOL. SOL.	
LBS. CARB. T.S./DAY TO DIGESTER	
LBS. CARB. T.V.S./DAY TO DIGESTER	
TOT. LBS. VOL. SOL./DAY TO DIGESTER	29176
C.F. GAS PROD./DAY/LB. V.S. ADDED	7.78

MAN DAYS AT PLANT ___ PAYROLL/MO. $26,514.35
ELECTRICITY PURCHASED ___ K.W.H. $6,288.40
GAS PURCHASED (diesel) ___ C.F. $716.65
CHEMICALS & SUPPLIES $
MAINTENANCE $11,696.55
OTHER OPERATING COSTS $106.11
AMORTIZATION COSTS $
PAYMENTS TO DEPRECIATION FUND $
TOTAL $39,713.19
COST/M.G. SEW. TREAT. $92.91
COST/CAPITA/MO. $0.26
COST/1000 LB. B.O.D. REMOVED $35.84 (1108)
REVENUE RECEIVED $

*C-COMPOSITE; G-GRAB. WC = WEIGHTED COMPOSITE
APPEARANCE OF ACTIVATED SLUDGE GOOD
IF BULKING, IN WHAT PERIOD NONE
NUMBER OF SLUDGE BEDS CLEANED OR HRS. VACUUM FILTER RUN
QUANTITY OF DRY SLUDGE REMOVED
WEATHER CONDITIONS TOTAL PRECIPITATION 3.37" (FROM NORM -.18")
AVERAGE TEMP. OF RAW SEWAGE
OTHER REMARKS #3 DIGESTER OUT OF SERVICE

S.B.H. [illegible] (46-25M)

SEND TO BRANCH OFFICE
INDIANA STATE BOARD OF HEALTH

MONTHLY REPORT OF OPERATION
SEWAGE TREATMENT PLANT
ACTIVATED SLUDGE TYPE

REPORT FOR South Bend (CITY)
FOR MONTH OF September 1970
SIGNED BY Casimir B. [illegible] #2245

DAY OF MONTH	DAY OF WEEK (1)	PRECIPITATION—INCHES (2)	RAW SEWAGE—M.G.D. (3)	PRIMARY TREAT. ONLY—M.G.D. (4)	COMPLETE TREATMENT—M.G.D. (5)	STREAM FLOW—M.G.D. (6)	5-DAY B.O.D.—P.P.M. UPSTREAM OF S.T.P. (7)	5-DAY B.O.D.—P.P.M. DOWNSTREAM OF S.T.P. (8)	GRIT REMOVED FROM GRIT CHAMBER—CU. FT. (9)	CHEMICALS USED: D.O. OF RIVER UPSTREAM OF STP (10)	D.O. OF RIVER DOWNSTREAM OF STP (11)	% OF SATURATION DOWNSTREAM OF STP (12)
1	T	—	38.1	—	38.1	—	—	—	78			
2	W	.25	36.8	5.5	31.3	—	—	—	68			
3	Th	.53	41.5	2.6	32.9	—	—	—	105			
4	F	—	38.5	0.9	37.6	—	—	—	105			
5	S	—	34.7		34.7	—	—	—	105			
6	Su	.46	33.6	0.6	33.0							
7	M	.21	37.2	2.7	34.4				135			
8	T	.25	43.4	3.3	40.1	—	3.1	3.1	68	[illegible]	7.3	—
9	W		35.5	—	35.5	—	4.6	4.4	105	7.1	7.8	
10	Th	.54	37.4	—	37.4	—	3.8	3.8	105	7.9	7.6	87
11	F		37.5	—	37.5	—	3.2	3.3	105	7.4	7.5	85
12	S	.25	35.4	—	35.4	—			135			
13	Su	.21	39.9	2.3	37.6	—						
14	M	.23	41.7	4.0	37.7	—			135			
15	T	.33	46.1	4.8	41.3				105			
16	W	.01	45.2	0.8	37.4	—	[illegible]	3.5	105	7.5	7.7	83
17	Th	[illegible]	38.3		38.3	—	[illegible]	3.6	105	7.4	7.6	82
18	F	T	42.7	2.4	40.3				105			
19	S		37.5		37.5				105			
20	Su	—	34.8		34.8							
21	M	T	37.5		37.5	—	3.0	2.7	135	7.6	7.7	89
22	T	[illegible]	[illegible]	4.3	[illegible]	—	3.7	4.6	68	7.3	7.9	87
23	W	[illegible]	[illegible]	3.4	[illegible]	—	4.1	4.6	90	8.1	8.0	89
24	Th	.69	[illegible]	3.5	[illegible]				135			
25	F		[illegible]	1.2	39.7		3.5	2.7		7.5	7.5	85
26	S	.18	[illegible]	[illegible]	[illegible]				135			
27	Su		[illegible]	—	[illegible]				135			
28	M	—	36.5	—	36.5				45			
29	T	—	36.4	—	36.4		3.8	2.8	78	8.1	8.0	84
30	W	—	32.8	0.7	32.1				105			
31												
TOTAL			[illegible]	42.1	[illegible]				[illegible]			
AVERAGE			37.6	1.4	35.2	—	3.3	3.3	87	7.7	7.7	86
TYPE OF SAMPLE ANALYZED*							G	G		G	G	G
NO. OF PORTIONS COLLECTED DAILY							1	1		1	1	1

DAY OF MONTH	RAW SEWAGE PH (13)	RAW SEWAGE 5-DAY B.O.D.—P.P.M. (14)	RAW SEWAGE SUSP. SOLIDS—P.P.M. (15)	PRIMARY EFFLUENT PH (16)	PRIMARY EFFLUENT 5-DAY B.O.D.—P.P.M. (17)	PRIMARY EFFLUENT SUSP. SOLIDS—P.P.M. (18)	FINAL EFFLUENT PH (19)	FINAL EFFLUENT 5-DAY B.O.D.—P.P.M. (20)	FINAL EFFLUENT SUSP. SOLIDS—P.P.M. (21)	FINAL EFFLUENT DISSOLVED OXYGEN—P.P.M. (22)	RESIDUAL CHLORINE—P.P.M. (23)
1	7.4	112	130	7.5	41	59	7.7	16.1	8.0	2.2	
2	7.4	132	99	7.5	81	62	7.7	13.9	9.5	2.2	—
3	7.6	138	136	7.6	95	28	7.9	16.5	12.5	1.9	—
4		143			106			10.3		3	
5	7.2	133	63	[illegible]	108	38	7.1	15.6	11	3.3	—
6	7.4	132	78	7.5	92	39	7.6	14.7	[illegible]	[illegible]	—
7	7.6	91	86	7.7	64	47	7.9	15.1	9.0	2.3	—
8	7.6	121	108	7.6	92	70	7.9	14.5	9.0	2.6	—
9	7.8	103	111	7.8	85	56	8.1	14.7	13	2.9	—
10	7.6	123	95	7.6	113	44	7.8	15.2	8	2.2	—
11	7.2	141	76	7.5	103	57	7.7	13.9	9.75	1.3	—
12	7.6	126	173	7.6	57	70	7.8	14.5	18.5	2.8	—
13	7.7	125	59	7.7	71	42	8.0	13.5	3.5	3.0	—
14	7.3	147	190	7.4	97	84	7.4	[illegible]	11.5	3.2	—
15	7.6	130	51	7.5	86	40	7.4	[illegible]	15	2.3	—
16	7.3	116		7.1	59		7.4	12.3		1.4	—
17	7.4	134	119	7.5	107	66	7.7	16.4	7.3	3.0	—
18	7.5	125	221	7.5	97	25	7.7	12.7	6.0	3.0	—
19	7.6	157	75	7.7	107	77	7.8	5.6	16.5	3.3	—
20	7.6	155	76	7.7	101	13	7.8	16.2	14.5	3.4	—
21	7.4	131	101	7.5	91	34	7.6	14.5	14	2.5	—
22	7.7	126	188	7.6	91	16	7.8	14.7	12	1.8	—
23	7.6	119	143	7.6	55	77	7.8	13.3	11	2.2	—
24	7.3	[illegible]	234	7.4	73	45	7.8	10	14	3.1	—
25	7.5	127	132	7.6	82	63	7.8	12.1	17	3.6	—
26	7.7	115	123	7.8	51	59	7.9	13.9	15.5	3.7	—
27	7.8	119	55	7.5	86	34	7.9	14	13.5	2.2	—
28	7.2	112	131	7.6	69	60	7.6	13.7	7.6	2.2	—
29	7.8	156	130	7.7	117	86	7.7	16.5	16	2.1	—
30	7.8	132	127	7.8	95	73	7.9	16.5	15	3.1	—
31											
TOTAL											
AVERAGE	7.5	130	118	7.6	91	62	7.8	14.5	14	2.8	—
TYPE OF SAMPLE ANALYZED*	WC	WC	WC	WC	WC	WC	WC	WC	WC	G	
NO. OF PORTIONS COLLECTED DAILY	24	24	24	24	24	24	24	24	24	9	

DAY OF MONTH	AERATION, MIXED LIQUOR: SETTLEABLE SOLIDS % IN 30 MINUTES (24)	SUSP. SOLIDS—P.P.M. (25)	SLUDGE INDEX (26)	DISSOLVED OXYGEN—P.P.M. (27)	AIR USED IN AERATION MILLION CU. FT. (28)	RETURN SLUDGE: VOLUME—M.G.D. (29)	RETURN SLUDGE: SUSP. SOLIDS—P.P.M. (30)
1	18	2176	73	3.1	22.3	10.6	2820
2	20	1996	104	3.3	20.0	10.7	7846
3	19	2633	72	2.5	20.2	10.6	6530
4				3.0	19.5	10.6	
5	21	2422	87	5.1	18.5	10.6	7376
6				5.1	19.7	10.7	
7	17	1882	90	5.1	12.7	10.5	7290
8	15	1734	82	3.9	19.4	10.6	10380
9	18	2188	83	3.9	19.6	10.7	7450
10	21	2286	92	3.8	18.7	10.6	8300
11	22	2350	92	2.7	26.1	10.5	8030
12				4.9	20.4	10.5	
13				4.9	22.5	10.7	
14	19	2154	88	5.1	20.7	10.7	10170
15	17	1940	88	3.4	19.1	10.6	10980
16	19	2380	79	3.6	[illegible]	10.6	5730
17	17	2334	80	3.2	18.5	10.8	6710
18	19	2332	72	4.6	19.0	10.6	8640
19				4.2	[illegible]	10.8	
20				4.6	19.3	10.5	
21	16	2070	77	4.4	12.0	10.6	8650
22	16	1844	87	3.5	18.6	10.6	7390
23	19	2256	85	3.6	16.7	10.6	6230
24	18	2178	83	3.9	18.8	10.4	10240
25	21	2566	84	3.7	18.8	10.4	9270
26				2.5	19.0	10.5	
27				4.6	19.6	10.5	
28	16	1788	90	3.0	18.9	10.5	5680
29	18	2200	82	3.8	18.1	10.6	7720
30	19	2516	76	3.8	19.0	10.5	8260
31							
TOTAL					582.6	317	
AVERAGE	18.5	2170	87	4.0	19.4	10.9	8272
TYPE OF SAMPLE ANALYZED*	G	G	G	G			G
NO. OF PORTIONS COLLECTED DAILY	1	1	1	18			1

DAY OF MONTH	SLUDGE DIGESTION: WASTE ACT. SLUDGE ~~GAL. X 1000~~ WET WT (31)	RAW SLUDGE TO DIGESTER—GAL. X 1000 (32)	TOTAL SOLIDS IN RAW SLUDGE—% (33)	TOTAL VOL. SOLIDS IN RAW SLUDGE—% (34)	TEMPERATURE IN DIGESTER—°F. (35)	PH IN DIGESTER (36)	GAS PRODUCTION CU. FT. X 1000 (37)	GAS USED CU. FT. X 1000 (38)	SUPERNATANT WITHDRAWN—GAL. X 1000 (39)	SOLIDS IN SUPERNATANT—% (40)	SLUDGE WITHDRAWN GAL. X 1000 (41)	TOTAL SOLIDS IN DIGESTED SLUDGE—% (42)	TOTAL VOL. SOLIDS IN DIGESTED SLUDGE—% (43)
1	72	144	4.0	74	94	7.1	221	221			123	4.2	52
2	180	150	3.5	74	94	7.0	251	251			129	4.2	57
3	360	126	4.0	74	85	7.0	252	253	132	0.48			
4	215	153	4.2	67	96	7.0	201	201			102	4.9	50
5	335	132	3.5	71	96	7.1	251	251	49		74	2.8	45
6	123	132	3.3	65	96	7.1	234	234	162	0.14			
7	127	124	4.5	58	96	7.1	238	238	132	0.48	156	3.8	41
8	130	126	4.5	63	96	7.1	215	215	183	0.24	231	3.0	28
9	95	144	3.2	62	96	7.0	207	207					
10	315	129	3.5	73	96	7.1	229	229					
11	346	123	3.2	76	96	7.1	186	186					
12	369	127	3.8	68	96	7.1	229	229			132	3.2	51
13	120	132	4.6	65	96	7.1	154	154	210	0.80	36	3.9	43
14	330	125	4.4	60	95	7.0	144	144					
15	123	96	5.0	59	95	7.0	228	207					
16	216	99	5.2	64	96	7.0	207	207					
17	168	126	3.7	57	96	7.1	191	191					
18	[illegible]	114	5.4	61	96	7.1	187	187	[illegible]	0.25	162	4.9	55
19	360	114	5.2	62	96	7.1	171	171	159	0.46			
20	360	123	4.6	66	96	7.1	219	219	12	0.40	144	4.8	54
21	132	120	3.7	70	96	7.1	185	185			96	4.2	52
22	242	135	4.2	73	96	7.1	152	152	216	0.60			
23	146	144	4.4	72	96	7.1	125	125			60	4.1	54
24	335	153	3.6	36	96	7.1	209	204	156	0.70	225	3.1	41
25	335	126	3.8	63	96	7.1	229	229	36		36		
26	216	162	4.3	64	96	7.1	260	260	170				
27	225	132	4.4	63	96	7.0	252	252	216	1.0			
28		150	3.9	65	96	7.1	253	253					
29	311	132	3.8	62	96	7.1	176	176			156	3.8	41
30	450	114	4.1	68	97	7.0	223	223	142	0.24			
31													
TOTAL	6659	3927					6364	6349	2014		1875		
AVERAGE	222	131	4.1	65	96	7.1	212	211	69	0.56	63	3.9	48
TYPE OF SAMPLE ANALYZED*			C	C		C				C		C	C
NO. OF PORTIONS COLLECTED DAILY			34	24		8				12		8	8

*C—COMPOSITE: G—GRAB. WC = WEIGHTED COMPOSITE

APPEARANCE OF ACTIVATED SLUDGE GOOD

NUMBER OF SLUDGE BEDS CLEANED OR HRS. VACUUM FILTER RUN ____

WEATHER CONDITIONS TOTAL PRECIPITATION 5.37" (+2.3" FROM NORM)

OTHER REMARKS #3 DIGESTER OUT OF SERVICE

IF BULKING, IN WHAT PERIOD NONE

QUANTITY OF DRY SLUDGE REMOVED ____

AVERAGE TEMP. OF RAW SEWAGE ____

S.B.H. 3-0-35

SUMMARY DATA

PERCENT PURIFICATION	B.O.D.	S.S.
PRIMARY TREATMENT	.30	47.5
SECONDARY TREATMENT	84	77.4
OVERALL TREATMENT	88.8	79

DETENTION TIME—HOURS	MAX.	MIN.	AVE.
PRIMARY SETTLING TANK	1.85	1.38	1.66
AERATION TANK ✗	3.56	2.95	3.19
FINAL SETTLING TANK	2.20	1.72	1.90

✗ MIXED LIQUOR FLOW

SURFACE FLOW RATE GAL. SQ. FT. DAY	MAX.	MIN.	AVE.
PRIMARY SETTLING TANK	1242	875	1031
FINAL SETTLING TANK ✗✗	1390	1074	1255

✗✗ SEC INFLUENT FLOW

WEIR OVERFLOW RATE GAL./FT. OF WEIR DAY	MAX.	MIN.	AVE.
PRIMARY SETTLING TANK	9250	7925	9340
FINAL SETTLING TANK	11495	7925	10335

EST. CENS. POP. 150,000

EQUIV. POP. TREATED = 253,582
(LBS. B.O.D. RAW SEWAGE ÷ 0.17)
LBS S.S. RAW SEWAGE ÷ 0.2 = 194,875

C.F. AIR/GAL. SEW. TREATED	0.568
C.F. AIR/LB. B.O.D. REMOVED IN SECONDARY TREATMENT	796
LBS. B.O.D. APPLIED TO AERATOR PER 1000 C.F. AERATOR CAP.	33.56

GARB. TO DIGESTER—% TOT. SOLIDS	
GARB. TO DIGESTER—% TOT. VOL. SOL.	
LBS. GARB. T.S./DAY TO DIGESTER	
LBS. GARB. T.V.S./DAY TO DIGESTER	
TOT. LBS. VOL. SOL. DAY TO DIGESTER	29098
C.F. GAS PROD./DAY/LB. V.S. ADDED	7.29

MAN DAYS AT PLANT ____ PAYROLL, MO. $24146.53
ELECTRICITY PURCHASED ____ K.W.H. $1614.50
& Oil GAS PURCHASED ____ C.F. $1402.72
CHEMICALS & SUPPLIES $____
MAINTENANCE $1121.90
OTHER OPERATING COSTS $[illegible]
AMORTIZATION COSTS $____
PAYMENTS TO DEPRECIATION FUND $____
TOTAL $28561.33
COST/M.G. SEW. TREAT. $29.70
COST/CAPITA/MO. $0.248
COST/~~1000~~ 1118 LB. B.O.D. REMOVED $24.49
REVENUE RECEIVED $____

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SEND TO BRANCH OFFICE
INDIANA STATE BOARD OF HEALTH

MONTHLY REPORT OF OPERATION
SEWAGE TREATMENT PLANT
ACTIVATED SLUDGE TYPE

REPORT FOR South Bend (CITY)
FOR MONTH OF October 1970
SIGNED BY Casimir B. Przymiki #2245

DAY OF MONTH	DAY OF WEEK (1)	PRECIPITATION—INCHES (2)	RAW SEWAGE ~~[illegible]~~—M.G.D. (3)	PRIMARY TREAT. ONLY—M.G.D. (4)	COMPLETE TREATMENT—M.G.D. (5)	STREAM FLOW—M.G.D. TEMP OF RIVER °F (6)	5-DAY B.O.D.—P.P.M. UPSTREAM OF S.T.P. (7)	5-DAY B.O.D.—P.P.M. DOWNSTREAM OF S.T.P. (8)	GRIT REMOVED FROM GRIT CHAMBER—CU. FT. (9)	CHEMICALS USED: D.O. of River—Upstream of S.T.P. (10)	D.O. of River—Downstream of S.T.P. (11)	% of Saturation [illegible] (12)
1	[illegible]		37.8		37.0	64	4.3	4.4	105	9.2	9.2	10.9
2	[illegible]	T	37.2	2.4	[illegible]	—	4.3	—	68	9.1	9.2	9.6
3	[illegible]	—	36.2	—	36.2			—	68			
4	[illegible]		32.4	—	32.4							
5	M	T	38.3	—	35.3	59	6.0	6.5	135	9.6	9.5	9.4
6	T	T	40.3	1.6	38.7	63	6.6	6.4	105	9.7	9.5	9.7
7	[illegible]	T	39.2	0.7	39.0	—	—	—	68	—	—	—
8	[illegible]	.17	42.1	2.5	39.6				105			
9	F	.14	43.1	3.3	39.8	63	4.4	4.8	105	9.1	9.6	9.3
10	S		35.9	—	35.9	—		—	68	—	—	—
11	S		32.4		32.4				105			
12	M	.25	32.3	1.7	31.9							
13	T	.32	40.7	1.5	39.2				68			
14	[illegible]	.12	50.0	7.8	42.2	63	6.3	6.5	68	8.7	8.7	8.9
15	[illegible]	—	39.8	—	39.8	59	3.1	4.0	105	9.6	7.8	12.6
16	F	—	37.9	0.4	37.5	57	4.6	4.8	105	11.0	11.1	10.9
17	S	—	31.7	—	31.7				68			
18	S	—	34.8	—	34.8				105			
19	M	—	39.5	1.6	37.9							
20	T	.22	40.6	1.9	39.1	59	6.6	7.5	68	13.4	13.4	13.1
21	[illegible]	—	40.9	1.5	38.9	56	3.1	3.3		10.3	10.4	9.2
22	[illegible]	—	37.5	—	36.5	56	2.0	2.1	68	9.6	10.7	10.0
23	F	—	36.9	—	36.9				68			
24	S	—	35.6	—	35.6				68			
25	S	—	34.5	—	34.5							
26	M	—	36.2	1.3	34.9				135			
27	T	.15	36.9		36.9				135			
28	[illegible]	.73	42.1	3.2	38.7	63	3.5	3.6	68	9.2	9.2	9.4
29	[illegible]	.62	41.3	0.8	40.5	64	3.5	3.5	135	10.2	10.2	10.3
30	F		36.3	—	36.3	63	3.7	3.9	68	10	10	10.2
31	S	T	33.3		33.3				135			
TOTAL			1177	[illegible]	1169				2397			
AVERAGE			37.5	1.0	37.5	61	4.5	4.7	77	10	10	10.0
TYPE OF SAMPLE ANALYZED*						G	G			G	G	G
NO. OF PORTIONS COLLECTED DAILY						7	1			1	1	1

DAY OF MONTH	RAW SEWAGE PH (13)	RAW SEWAGE 5-DAY B.O.D.—P.P.M. (14)	RAW SEWAGE SUSP. SOLIDS—P.P.M. (15)	PRIMARY EFFLUENT PH (16)	PRIMARY EFFLUENT 5-DAY B.O.D.—P.P.M. (17)	PRIMARY EFFLUENT SUSP. SOLIDS—P.P.M. (18)	FINAL EFFLUENT PH (19)	FINAL EFFLUENT 5-DAY B.O.D.—P.P.M. (20)	FINAL EFFLUENT SUSP. SOLIDS—P.P.M. (21)	DISSOLVED OXYGEN—P.P.M. (22)	[illegible] (23)
1	7.7	101	76	7.7	69	57	8.0	14	12	2.1	6.5
2	7.3	145	94	7.2	103	65	8.0	13.2	6.0	2.6	6.6
3	7.2	118	101	7.8	87	54	8.0	13.3	9.5	3.1	6.5
4	7.7	119	69	7.7	24	52	8.0	14.1	7.5	3.2	6.5
5	7.6	109	137	7.7	75	68	7.8	14	10	1.8	6.4
6	7.8	114	135	7.6	72	66	7.8	12.9	13.5	1.2	6.6
7	7.1	93	93	7.6	63	49	7.8	14.1	10	2.1	6.7
8	7.7	143	154	7.1	105	53	8.0	14.6	10	2.0	6.7
9	7.4	105	151	7.6	70	45	7.7	15.1	1.5	1.2	6.6
10										3.7	
11	7.3	69	61	7.4	42	59	7.6	7.3	14.5	3.4	6.3
12	7.1	143	115	7.2	100	64	7.5	10.5	10.5	4.0	6.4
13	7.1	150	171	7.1	108	69	7.2	14.3	9.5	1.7	6.6
14	7.2	149	231	7.4	28	116	7.3	13.7	17.5	3.1	6.6
15	7.8	145	103	7.6	95	59	7.8	11.7	2.0	3.7	6.3
16	7.7	93	104	7.3	75	56	7.5	13.5	9.3	4.3	6.3
17	7.6	126	82	7.5	100	45	7.8	17.3	11	3.1	6.2
18	7.4	55	56	7.3	74	55	7.6	16.3	15	2.5	6.2
19	7.9	140	124	7.7	100	57	7.7	15.4	11	3.0	6.3
20	7.1	138	116	7.7	94	58	7.9	14.1	2	2.9	6.3
21	7.5	97	133	7.7	71	52	7.8	12.6	13	2.8	6.4
22	7.6	142	124	7.7	107	61	7.7	15.7	12.5	3.0	6.9
23	8.1	138	161	7.9	90	76	8.2	12.8	14.5	3.3	6.4
24	7.8	70	205	7.8	60	209	8.1	12.1	15	3.7	6.4
25	7.9	91	84	7.8	57	70	8.0	13.9	11	4.3	6.4
26	7.8	161	202	7.8	134	87	8.0	16.1	14.5	2.8	6.3
27	7.5	117	125	7.6	100	61	7.2	12	1.2	3.2	6.4
28	7.5	153	231	7.5	100	102	7.7	14.4	8	4.2	6.4
29	7.4	156	91	7.6	113	82	7.9	13.7	22	3.3	6.3
30	7.2	131	141	7.6	101	80	7.8	13.2	23.5	1.9	6.4
31	7.7	104	100	7.7	67	82	8.0	13.5	22	3.4	6.3
TOTAL											
AVERAGE	7.6	123	123	7.5	87.4	72	7.8	13.9	11.9	2.9	6.4
TYPE OF SAMPLE ANALYZED*	WC	WC	WC	WC	WC	WC	WC	WC	WC	C	G
NO. OF PORTIONS COLLECTED DAILY	24	24	24	24	24	24	24	24	24	9	24

DAY OF MONTH	AERATION MIXED LIQUOR SETTLEABLE SOLIDS % IN 30 MINUTES (24)	SUSP. SOLIDS—P.P.M. (25)	SLUDGE INDEX (26)	DISSOLVED OXYGEN—P.P.M. (27)	AIR USED IN AERATION MILLION CU. FT. (28)	RETURN SLUDGE VOLUME—M.G.D. (29)	RETURN SLUDGE SUSP. SOLIDS—P.P.M. (30)
1	17	2129	78	4.3	19.1	10.7	7790
2	19	2010	94	3.9	19.2	10.7	7460
3				4.3	19.0	10.6	
4				4.3	17.2	10.7	
5	17	2004	85	3.0	12.9	10.6	7010
6	21	2142	98	1.9	12.2	10.6	7220
7	19	2122	90	2.8	19.3	10.6	
8	21	2374	89	3.6	19.5	10.6	8460
9				2.2	18.8	10.6	
10				3.4	18.7	10.6	
11				4.8	18.8	10.5	
12				4.7	12.7	10.8	
13	20	2111	92	2.2	12.6	10.6	7160
14	19	1864	102	3.9	12.8	10.5	11760
15	20	2422	83	5.1	19.2	10.5	7320
16	17	2096	81	6.0	14.7	10.5	6910
17				4.7	18.6	10.7	
18				4.5	19.7	10.8	
19	16	2196	75	5.3	12.5	10.5	8160
20				3.3	14.5	10.5	
21	19	2214	86	3.1	19.3	10.6	8470
22	20	2296	87	3.4	17.4	10.5	8460
23	18	2234	81	3.9	19.1	10.5	7340
24				5.6	19.4	10.6	
25				5.6	19.5	10.6	
26	14	1160	84	4.0	19.7	10.5	7650
27	18	2350	80	3.7	20.1	10.6	8010
28	17	2750	62	6.0	20.2	10.5	9370
29	17	2216	77	4.0	20.3	10.4	7420
30				3.5	21.8	10.5	
31				4.4	19.8	10.3	
TOTAL					602.9	328	
AVERAGE	19	2188	84	4.0	19.9	10.6	7995
TYPE OF SAMPLE ANALYZED*	G	G	G	G			G
NO. OF PORTIONS COLLECTED DAILY	1	1	1	18			1

DAY OF MONTH	SLUDGE DIGESTION: WASTE ACT. SLUDGE—GAL. X 1000 (31)	RAW SLUDGE TO DIGESTER—GAL. X 1000 (32)	TOTAL SOLIDS IN RAW SLUDGE—% (33)	TOTAL VOL. SOLIDS IN RAW SLUDGE—% (34)	TEMPERATURE IN DIGESTER—°F. (35)	PH IN DIGESTER (36)	GAS PRODUCTION CU. FT. X 1000 (37)	GAS USED CU. FT. X 1000 (38)	SUPERNATANT WITHDRAWN—GAL. X 1000 (39)	SOLIDS IN SUPERNATANT—% (40)	SLUDGE WITHDRAWN GAL. X 1000 (41)	TOTAL SOLIDS IN DIGESTED SLUDGE—% (42)	TOTAL VOL. SOLIDS IN DIGESTED SLUDGE—% (43)
1	234	120	3.8	70	97	7.2	235	235	30	1.51	42	2.4	42
2	118	132	3.9	72	97	7.1	122	122					
3	218	126	3.8	74	97	7.1	177	177	198	0.61	180	4.6	37
4	234	144	4.1	67	97	7.2	220	220					
5	82	135	3.8	68	97	7.2	286	286	198	0.70	180	4.9	42
6	402	114	4.1	70	98	7.1	158	158					
7	144	123	3.8	70	98	7.1	171	171					
8	468	126	4.3	67	97	7.1	228	228	198	0.49	186	4.5	48
9	312	138	4.4	70	97	7.1	205	205					
10	312	147			97		226	226					
11	150	141	3.3	74	96	7.0	227	227					
12	420	121	3.8	76	96	7.1	247	247	204	0.55	174	3.7	54
13	83	135	3.6	74	96	7.0	215	215					
14	246	135	4.4	64	96	7.1	213	213					
15	420	141	3.1	64	96	7.1	251	251	162	0.60	228	4.4	50
16	328	141	4.4	55	97	7.0	241	241					
17	168	132	4.1	63	96	7.0	266	266					
18	168	123	4.0	68	96	7.1	272	272	138	0.60	252	3.9	51
19	252	136	3.9	65	96	7.1	232	232					
20	151	120	3.9	67	96	7.1	131	131					
21	344	93	4.3	66	96	7.1	207	207			378	3.0	47
22	144	108	3.9	64	96	7.2	183	183					
23		132	4.2	58	96	7.2	198	198					
24	631	105	4.3	60	96	7.2	235	235					
25	156	120	4.0	69	96	7.1	229	229	210	1.5	174	4.9	59
26		144	3.7	74	96	7.1	234	234					
27	156	129	4.0	74	96	7.1	228	228					
28	402	132	4.3	70	96	7.1	214	214			390	2.4	50
29	336	137	4.3	75	96	7.2	254	254					
30	248	126	4.3	68	97	7.1	194	194					
31	538	126	3.9	69	97	7.0	203	203	174	1.05	210	3.3	30
TOTAL	8298	3978					6934	6934	1512		2718		
AVERAGE	268	128	4.1	68	96.5	7.1	224	224	[illegible]	0.87	72	3.8	47
TYPE OF SAMPLE ANALYZED*			C	C		C				C		C	C
NO. OF PORTIONS COLLECTED DAILY			24	24		8				12		8	8

*C-COMPOSITE: G-GRAB. W.C = WEIGHTED COMPOSITE

APPEARANCE OF ACTIVATED SLUDGE GOOD

IF BULKING, IN WHAT PERIOD NONE

NUMBER OF SLUDGE BEDS CLEANED OR HRS. VACUUM FILTER RUN

QUANTITY OF DRY SLUDGE REMOVED

WEATHER CONDITIONS TOTAL PRECIPITATION 3.68" (+ .51" FROM NORM)

AVERAGE TEMP. OF RAW SEWAGE (SEC. DIG)

OTHER REMARKS #3 DIGESTER STILL OUT OF SERVICE - OCT. 21428 DIGESTED SLUDGE DRAWN FROM #4 DIG. THAT WAS BEING RECIRCULATED & HEATED

S.B.H. 50-20 [illegible]

SUMMARY DATA

PERCENT PURIFICATION	B.O.D.	S.S.
PRIMARY TREATMENT	29.0	41.5
SECONDARY TREATMENT	84.1	83.5
OVERALL TREATMENT	88.7	91.3

DETENTION TIME - HOURS	MAX.	MIN.	AVE.
PRIMARY SETTLING TANK	2.13	1.31	1.70
AERATION TANK *	3.60	2.95	3.24
FINAL SETTLING TANK	2.24	1.72	1.94

* MIXED LIQUOR FLOW

SURFACE FLOW RATE GAL. SQ. FT./DAY	MAX.	MIN.	AVE.
PRIMARY SETTLING TANK	1362	844	1083
FINAL SETTLING TANK **	1386	1064	1233

** = SEC. INFLUENT FLOW

WEIR OVERFLOW RATE GAL. FT. OF WEIR DAY	MAX.	MIN.	AVE.
PRIMARY SETTLING TANK	11723	7642	9090
FINAL SETTLING TANK	11418	3766	10145

EST. CONN. POP = 180,000

EQUIV. POP. TREATED: [illegible] 232,318

[illegible] S.S. RAW SEWAGE ÷ 0.2 = 177470

C. F. AIR/GAL. SEW. TREATED	0.517
C.F. AIR/LB. B.O.D. REMOVED IN SECONDARY TREATMENT	844
LBS. B.O.D. APPLIED TO AERATOR PER 1000 C.F. AERATOR CAP.	31.64

GARB. TO DIGESTER—% TOT. SOLIDS	
GARB. TO DIGESTER—% TOT. VOL. SOL.	
LBS. GARB. T.S./DAY TO DIGESTER	
LBS. GARB. T.V.S./DAY TO DIGESTER	
TOT. LBS. VOL. SOL./DAY TO DIGESTER	29762
C.F. GAS PROD. DAY/LB. V.S. ADDED	7.53

MAN DAYS AT PLANT ___ PAYROLL/MO. $ 23,758.85
ELECTRICITY PURCHASED ___ K.W.H. $ 14,227.20
& C.I.S.
GAS PURCHASED ___ C.F. $ 494.03
CHEMICALS & SUPPLIES $
MAINTENANCE $ 12,993.85
OTHER OPERATING COSTS $ 459.43
AMORTIZATION COSTS $
PAYMENTS TO DEPRECIATION FUND $
TOTAL $ 37,068.81
COST/M.G. SEW. TREAT. $ 23.56
COST/CAPITA/MO. $ 0.25
1067
COST/1000 LB. B.O.D. REMOVED $ 36.61
REVENUE RECEIVED $

SEND TO BRANCH OFFICE
INDIANA STATE BOARD OF HEALTH

MONTHLY REPORT OF OPERATION
SEWAGE TREATMENT PLANT
ACTIVATED SLUDGE TYPE

REPORT FOR South Bend (CITY)
FOR MONTH OF November 1970
SIGNED BY Casimir B. Przepnicki #2345

DAY OF MONTH	DAY OF WEEK	PRECIPITATION—INCHES	RAW SEWAGE—M.G.D.	PRIMARY TREAT. ONLY—M.G.D.	COMPLETE TREATMENT—M.G.D.	TEMP OF RIVER °F	5 DAY B.O.D.—P.P.M. UPSTREAM OF S.T.P.	5 DAY B.O.D.—P.P.M. DOWNSTREAM OF S.T.P.	GRIT REMOVED FROM GRIT CHAMBER—CU. FT.	CHEMICALS USED: D.O. OF RIVER UPSTREAM OF S.T.P.	CHEMICALS USED: D.O. OF RIVER DOWNSTREAM OF S.T.P.	CHEMICALS USED: % OF SATURATION DOWNSTREAM	RAW SEWAGE: pH	RAW SEWAGE: 5-DAY B.O.D.—P.P.M.	RAW SEWAGE: SUSP. SOLIDS—P.P.M.	PRIMARY EFFLUENT: pH	PRIMARY EFFLUENT: 5-DAY B.O.D.—P.P.M.	PRIMARY EFFLUENT: SUSP. SOLIDS—P.P.M.	FINAL EFFLUENT: pH	FINAL EFFLUENT: 5-DAY B.O.D.—P.P.M.	FINAL EFFLUENT: SUSP. SOLIDS—P.P.M.	FINAL EFFLUENT: DISSOLVED OXYGEN—P.P.M.	Final-Effluent Temp °F
1	2	3	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	[illegible]	—	31.7	—	31.7	55	—	—	135				7.5	102	92	7.5	65	84	7.7	13.1	22	3.8	6.2
2	[illegible]	[illegible]	41.8	3.3	38.5		3.1	3.7		11.2	11.3	100	7.4	130	183	7.3	94	152	7.8	13.3	15.5	3.3	6.0
3	[illegible]	[illegible]	[illegible]	0.8	37.2	54			105				7.7	138	113	7.5	98	111	7.6	15.2	30	3.8	5.6
4	[illegible]	.25	37.2	2.1	35.1	51	4.5	4.6	135	11.6	11.6	107	7.8	128	89	7.9	96	66	8.1	14.9	11.5	4.1	5.9
5	[illegible]	—	37.6	—	37.6	54	2.6	2.7	18	11.2	11.2	103	7.7	120	119	7.7	85	69	8.0	13	16	3.1	6.1
6	[illegible]	—	37.8	—	37.8	—	4.0	4.3	18	11.3	11.4	105	7.4	145	121	7.6	77	62	7.7	10.8	6.5	2.3	6.0
7	[illegible]	—	36.4	—	36.4	—			135				7.6	62	93	7.6	53	73	7.9	8.6	15	2.9	6.1
8	[illegible]	—	34.0	—	34.0	57		—		—	—	—	8.1	81	123	7.8	66	82	8.1	10.9	14.5	3.8	6.1
9	[illegible]	[illegible]	40.2		37.9	56	3.2	3.5	105	12	12.1	105	7.6	120	165	7.5	93	87	7.7	14.7	11	4.4	6.1
10	[illegible]	[illegible]	42.1	7.9	40.2		5.0	4.7	105	12.2	12	114	7.6	137	122	7.5	98	84	7.9	14.2	14.5	3.4	6.1
11	[illegible]	[illegible]	35.1	—	35.1	56							7.6	122	119	7.6	88	64	7.7	11.5	7.5	2.5	6.2
12	[illegible]	—	38.3	—	38.3	—	3.0	3.2	135	12.3	12.6	94	7.6	157	115	7.5	104	77	7.8	11	18	3.1	6.1
13	[illegible]	—	38.0		38.0	—	5.1	6.0	67	11.5	11.5	—	7.4	128	163	7.7	105	123	7.7	11.5	11.5	[illegible]	6.1
14	[illegible]		36.1	—	36.1		—	—	135	—	—	—	7.5	119	99	7.6	80	91	7.9	12	19	4.1	6.0
15	[illegible]	[illegible]	34.1	—	34.1	48				—	—	—	7.8	134	94	7.7	75	63	7.9	11.2	24.5	3.5	5.8
16	[illegible]	—	37.3	—	37.3	45	51	55	105	13	13.1	113	7.6	171	153	7.6	104	78	7.9	16.5	11	4.5	5.9
17	[illegible]		37.7	—	37.7	41	5.4	5.5	68	14.1	14.2	116	7.7	110	176	7.7	79	77	7.9	10.8	16.5	3.7	5.9
18	[illegible]	[illegible]	38.1	0.5	37.6	41	4.9	5.1	67	12	13.1	103	7.5	156	124	7.6	109	44	7.9	15.6	40	2.5	5.9
19	[illegible]	[illegible]	37.4		37.4	45	4.1	4.4	65	12.1	12.4	101	7.6	134	125	7.6	96	65	7.8	13.4	11	3.2	6.0
20	[illegible]	[illegible]	45.9	4.6	41.3	—	1.9	2.1	68	12	12.1	103	7.6	174	210	7.7	109	98	7.9	13.2	11	2.8	6.0
21	[illegible]		35.3	—	35.3	41	—	—	68	—	—	—	—	134	41	—	97	39	—	22	22	4.3	5.9
22	[illegible]	[illegible]	37.4	—	37.4	—		—		—	—	—	—	138	67	—	97	54	—	13.1	6.0	4.4	5.7
23	[illegible]	[illegible]	36.9	—	36.9	—	3.5	5.5	105	14.1	14.2	111	7.1	131	121	7.2	95	24	7.7	13.5	5.0	3.7	5.2
24	[illegible]	[illegible]	37.8	—	37.8	—	—	—	37	—	—	—	7.6	145	119	7.7	96	90	7.7	14.7	10	2.2	5.6
25	[illegible]	[illegible]	37.9	—	37.9	—	—	—	68	—	—	—	7.6	139	132	7.6	93	66	7.9	14.7	12	2.5	5.5
26	[illegible]	[illegible]	[illegible]		37.3	—	—	—	37	—	—	—	7.4	162	141	7.5	93	87	7.9	16.6	15	3.5	5.7
27	[illegible]	[illegible]	[illegible]		42.1	38	6.4	6.1	105	14.5	14.1	110	7.3	71	271	7.5	69	126	7.8	7.5	4.5	4.5	5.9
28	[illegible]	[illegible]	37.9	1.1	36.8	—		—	135	—	—	—	7.2	133	135	7.6	44	115	7.8	5.9	12	7.1	5.0
29	[illegible]	[illegible]	37.4	2.6	34.8	—	—	—	135	—	—	—	7.6	125	79	7.6	96	69	7.9	7.8	14	3.5	5.5
30	[illegible]	—	37.4	—	37.4	45	—	—	65	—	—	—	8.0	110	102	7.7	99	93	7.9	14.2	12.5	2.7	5.6
31																							
TOTAL			[illegible]	22.5	1122				2240														
AVERAGE			37.2	.75	37.4	50	4.6	4.8	26	12.2	12.5	108	7.6	130	124	7.6	91	80	7.9	12.6	13.5	3.5	5.8
TYPE OF SAMPLE ANALYZED*						G	G	G		G	G	G	WC	WC	WC	WC	WC	WC	WC	WC	WC	C	G
NO. OF PORTIONS COLLECTED DAILY						1	1	1		1	1	1	24	24	24	24	24	24	24	24	24	9	24

DAY OF MONTH	MIXED LIQUOR: SETTLEABLE SOLIDS % IN 30 MINUTES	MIXED LIQUOR: SUSP. SOLIDS—P.P.M.	MIXED LIQUOR: SLUDGE INDEX	MIXED LIQUOR: DISSOLVED OXYGEN—P.P.M.	AERATION: AIR USED IN AERATION MILLION CU. FT.	RETURN SLUDGE: VOLUME—M.G.D.	RETURN SLUDGE: SUSP. SOLIDS—P.P.M.	WASTE ACT. SLUDGE—GAL. X 1000 WET WELL	RAW SLUDGE TO DIGESTER—GAL. X 1000	TOTAL SOLIDS IN RAW SLUDGE—%	TOTAL VOL. SOLIDS IN RAW SLUDGE—%	TEMPERATURE IN DIGESTER—°F.	pH IN DIGESTER	GAS PRODUCTION CU. FT. X 1000	GAS USED CU. FT. X 1000	SUPERNATANT WITHDRAWN—GAL. X 1000	SOLIDS IN SUPERNATANT—%	SLUDGE WITHDRAWN GAL. X 1000	TOTAL SOLIDS IN DIGESTED SLUDGE—%	TOTAL VOL. SOLIDS IN DIGESTED SLUDGE—%
	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
1				5.5	21.7	10.3		331	141	4.2	69	96	7.2	215	215					
2	12	[illegible]	66	4.6	21.1	10.4	8370	92	157	3.7	65	96	7.2	238	238					
3	19	2142	88	5.0	21.2	10.4	8240	479	132	4.1	68	96	7.2	233	233			320	2.7	52
4	16	2186	73	4.8	21.4	10.4	9110	118	141	3.9	63	96	7.1	193	193					
5	17	2296	74	4.7	20.6	10.6	8150	473	147	3.9	67	96	7.1	215	215			234	7.6	60
6	18	2214	81	4.0	20.3	10.7	7610	352	147	3.8	69	96	7.1	250	250			150	1.8	57
7	—	—	—	4.2	21.2	10.6	—	328	174	3.6	66	97	7.1	242	242					
8	—	—	—	5.7	21.2	10.5	—	533	138	3.6	69	96	7.1	250	250	132	1.2	34	4.9	55
9	16	2230	80	5.6	21.3	10.4	6730		153	3.7	67	97	7.2	246	246					
10	20	2128	94	3.0	21.2	10.5	7930	566	144	4.0	64	97	7.1	232	232			72	1.8	50
11	19	1940	98	4.0	21.0	10.5	6660	328	138	4.5	70	97	7.0	233	232			318	1.8	55
12	19	2048	93	4.2	21.2	10.5	6710	164	147	4.0	70	97	7.0	268	268					
13	18	2010	90	4.0	21.1	10.5	2460	252	153	4.0	62	97	7.0	304	304	102	1.7	174	4.3	57
14	—	—	—	4.9	21.4	10.5	—	446	138	3.8	67	97	7.1	246	246	34	1.8	84	3.1	57
15	—	—	—	4.9	21.0	10.5	—	252	144	3.5	71	97	7.1	247	247			152	1.7	62
16	20	1568	133	6.0	21.3	10.6	10170	336	111	3.8	6.0	97	7.1	234	234			240	2.2	64
17	24	2208	105	4.8	21.2	10.4	7640	349	144	3.9	65	97	7.1	237	237					
18	24	1528	157	4.2	21.6	10.5	11110	320	138	4.5	62	97	7.1	301	301	39	2.1	198	4.7	56
19	21	2038	105	4.0	21.4	10.6	7760	492	126	4.3	65	97	7.1	247	247	72	0.4	75	2.8	61
20	21	1818	115	3.8	21.2	10.5	8660	410	123	4.2	68	97	7.1	261	261					
21	—	—	—	4.9	21.3	10.7	—	410	165	4.0	67	97	7.2	292	292			402	2.1	56
22	—	—	—	6.1	21.1	10.4	—	328	150	4.0	66	97	7.2	319	319					
23	31	1718	152	5.1	21.1	10.6	6320	164	198	3.8	65	96	7.2	302	302			252	2.1	45
24	33	1950	118	3.4	21.3	10.5	6640	248	165	4.1	61	95	7.1	280	280			138	2.9	55
25	35	2164	115	3.7	21.3	10.6	6960	281	147	3.8	71	96	7.2	278	278			328	2.8	52
26	—	—	—	4.3	21.2	10.7	—	360	135	3.8	76	97	7.1	241	241					
27	21	3162	77	5.7	21.0	10.6	9270	144	138	4.2	67	97	7.1	288	288					
28	—	—	—	7.9	21.2	10.5	—	137	132	5.2	60	97	7.2	323	323			320	2.6	49
29	—	—	—	4.1	21.2	10.5	—	187	135	4.0	61	97	7.1	239	239					
30	22	2464	89	4.9	21.2	9.9	8430	302	147	4.4	66	97	7.1	230	230					
31																				
TOTAL					635	315		9090	4345					7427		369		3671		
AVERAGE	19.8	2073	98	4.7	21.2	10.5	8049	303	145	4.0	66	97	7.1	250		123	1.5	122	2.6	56
TYPE OF SAMPLE ANALYZED*	G	G	G	G			G			C	C		C				C		C	C
NO. OF PORTIONS COLLECTED DAILY	1	1	1	18			1			24	24		24				12		8	8

*C—COMPOSITE: G—GRAB. WC = WEIGHTED COMPOSITE

APPEARANCE OF ACTIVATED SLUDGE GOOD

NUMBER OF SLUDGE BEDS CLEANED OR HRS. VACUUM FILTER RUN ______ IF BULKING, IN WHAT PERIOD NONE

WEATHER CONDITIONS Total PRECIPITATION 3.57" (+.92" FROM NORM) QUANTITY OF DRY SLUDGE REMOVED ______

OTHER REMARKS #3 DIGESTER-BACK IN SERVICE-DEC. 1, 1970 AVERAGE TEMP. OF RAW SEWAGE ______

S.B.H. 5-8-75 (10-25M)

SUMMARY DATA

PERCENT PURIFICATION	B.O.D.	S.S.
PRIMARY TREATMENT	30	37.5
SECONDARY TREATMENT	86.1	83.1
OVERALL TREATMENT	90.3	79.4

DETENTION TIME—HOURS	MAX.	MIN.	AVE.
PRIMARY SETTLING TANK	1.93	1.36	1.72
AERATION TANK *	3.49	0.95	3.24
FINAL SETTLING TANK	2.14	1.73	1.94

* MIXED LIQUOR FLOW

SURFACE FLOW RATE GAL. SQ. FT. DAY	MAX.	MIN.	AVE.
PRIMARY SETTLING TANK	1253	275	994
FINAL SETTLING TANK **	1383	1117	1325

** SEC. EFFLUENT FLOW

WEIR OVERFLOW RATE GAL. FT. OF WEIR DAY	MAX.	MIN.	AVE.
PRIMARY SETTLING TANK	11344	7019	9010
FINAL SETTLING TANK	11391	9200	10065

EST. CONN. POP. 150,000

EQUIV. POP. TREATED = 243635
(LBS. B.O.D. RAW SEWAGE ÷ 0.17)
LBS. S.S. RAW SEWAGE ÷ 0.2 = 203905

C. F. AIR/GAL. SEW. TREATED	0.567
C.F. AIR/LB. B.O.D. REMOVED IN SECONDARY TREATMENT	867
LBS. B.O.D. APPLIED TO AERATOR PER 1000 C.F. AERATOR CAP.	32.35

GARB. TO DIGESTER—% TOT. SOLIDS	
GARB. TO DIGESTER—% TOT. VOL. SOL.	
LBS. GARB. T.S./DAY TO DIGESTER	
LBS. GARB. T.V.S./DAY TO DIGESTER	
TOT. LBS. VOL. SOL./DAY TO DIGESTER	31936
C.F. GAS PROD./DAY/LB. V.S. ADDED	7.83

MAN DAYS AT PLANT ____ PAYROLL/MO. $ 35007.28
ELECTRICITY PURCHASED ____ K.W.H. $ 13191.16
GAS PURCHASED (fuel oil) ____ C.F. $ 1411.67
CHEMICALS & SUPPLIES $ ______
MAINTENANCE $ 6123.06
OTHER OPERATING COSTS $ 27.65
AMORTIZATION COSTS $ ______
PAYMENTS TO DEPRECIATION FUND $ ______
TOTAL $ 55756.96
COST/M.G. SEW. TREAT. $ 29.96 (.149)
COST/CAPITA/MO. $ 0.22 (155,000)
COST/1000 LB. B.O.D. REMOVED $ 50.97 (1106)
REVENUE RECEIVED $ ______